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THE

COMMERCIAL HAND-BOOK

OF

CHEMICAL ANALYSIS.

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THE
COMMERCIAL HAND-BOOK
OF
CHEMICAL ANALYSIS;
OR

PRACTICAL INSTRUCTIONS FOR THE DETERMINATION OF THE INTRINSIC OR
COMMERCIAL VALUE OF SUBSTANCES USED IN MANUFACTURES,
IN TRADES, AND IN THE ARTS.

BY

A. NORMANDY,

AUTHOR OF 'PRACTICAL INTRODUCTION TO ROSE'S CHEMISTRY,' 'THE CHEMICAL
ATLAS,' ETC., AND EDITOR OF ROSE'S 'TREATISE ON CHEMICAL ANALYSIS.'

NEW EDITION,

ENLARGED AND TO A GREAT EXTENT REWRITTEN,

BY

HENRY M. NOAD, PH.D., F.R.S.

AUTHOR OF 'A MANUAL OF CHEMICAL ANALYSIS,' 'THE STUDENT'S TEXT-BOOK OF
ELECTRICITY,' ETC. : LECTURER ON CHEMISTRY AT ST. GEORGE'S HOSPITAL.

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AUTHOR'S PREFACE.

If one of the principal characteristics of our epoch, from a commercial point of view, is the immense progress which every department of productive industry has achieved, it must be admitted that the arts of adulteration and sophistication have more than kept pace with the progress. These arts have invaded the luxuries and necessities of both the rich and the poor—raiment, food, medicine, furniture, the means of life, and the requirements of disease; all that can be mixed, hackled, twisted, ground, pulverized, woven, pressed; all articles of consumption in trade, in manufactures, in the arts; in a word, all that can be made matter of commerce and be sold, is adulterated, falsified, disguised, or drugged.

Yet it is necessary to make a distinction, for many things are denounced as adulterated, which strictly speaking are not so. For example, if by any contrivance a manufacturer succeed in making cloth or tissue in which a portion of wool or of silk, or of linen, is replaced by cotton (and such fabrics are constantly made, as every one knows), such articles are improperly said to be spurious; it is simply a new fabric which partakes of certain properties of each material, and *when sold for what it is*, there can be no ground for complaint; the public are clearly benefited by being able to procure articles answering the purpose and looking nearly, if not quite, as well as fabrics composed entirely of wool, silk, or linen, at a reduced price; and it is only when, on account of the close imitation, the seller succeeds in palming such articles on the unwary customer at, or nearly at, the price of the genuine goods, that the practice is to be deprecated; but in such a case the fraud clearly lies at the door of the seller, not at that of the maker; neither are the goods to be inveighed against because dishonestly sold for that which they are not, that is, under a false name, and at a price which they could not command if their nature were known.

When, however, sophistication is practised upon drugs or substances employed for manufacturing purposes, no such reasons can be pleaded, even in extenuation, for no benefit can possibly accrue to the public, even though the price be a reduced one, of an admixture of sulphate of barytes, or of chalk, for example, to white lead; of lamp-black to plumbago; of sulphate of potash to sulphuric acid, &c., &c.; and if adulteration be applied to medicinal agents, drugs, or ingredients, or to articles of food, the fraud becomes diabolical and unpardonable, for the addition of chalk, of plaster, of alum, to flour and to bread, of tallow and ochre to chocolate, of chromate of lead to tea, &c., not only affects the purchaser's purse, but destroys his health; whilst the substitution of flour for quinine, of clay or of Spanish liquorice for opium, of lead for mercury, of saltpetre for nitrate of silver, jeopardize at once the patient's life and the physician's name and character.

The object then of the present book is, it may be briefly stated, to indicate the various falsifications or the impurities which naturally, accidentally, or intentionally, may contaminate the various articles met with in commerce, and to enable the manufacturer, the miner, the trader, and the public generally, to detect the nature and amount of these sophistications and impurities; or, in other words, to ascertain the real or intrinsic value of such articles.

Hitherto this has been attained only by a regular analysis performed by the practical chemist. Several most valuable treatises of chemical analysis fully indicate, it is true, the methods by which such an analysis may be made; but these treatises, from the most complete downwards, are far too profound and elaborate to be of great use, except to the chemist or to the advanced chemical student; they require a previous competent knowledge of the science, and do not afford the slightest assistance to those who, not being very conversant with chemical matters, only wish to ascertain the purity or the actual amount of available matter contained in the substances manufactured or purchased by them.

In the same manner as a treatise of analytical chemistry indicates the methods by which compounds in general can be distinguished from each other, and their quantity determined, the 'COMMERCIAL HAND-BOOK OF CHEMICAL ANALYSIS' is intended to show the specific application of these methods to compounds of a particular kind, and in which the operator may have to examine whether they are contaminated by impurities, or sophisticated by fraudulent additions, and to what extent; or, in fact, whether the constituents known to exist in the genuine article are present, and in the proper degree.

In order to facilitate research, all the substances treated of have been put in alphabetical order; and several of these compounds being known under various names, they have been entered under all these names in their respective order, the reader being at the same time referred to the more modern appellation for the information required.

EDITOR'S PREFACE

TO

THE PRESENT EDITION.

IN this New Edition the alphabetical order of the substances treated of in the former has been retained. Every article has been carefully revised, and the latest processes for detecting impurities have been given. Many of the articles bearing on the sophistication of substances of domestic consumption, e.g., *bread*, *beer*, *butter*, *cheese*, *milk*, *tea*, *water*, *wine*, &c., have been greatly enlarged, and some new ones have been added.

As it has been my wish to make the work a 'Handy Book' not only for the efficient analyst discharging his duties under the new Adulterations Act, but for others also less conversant with the details of chemical analysis, a considerable development has been given to the 'Glossary,' which will be found to contain much new matter on the subject of 'Chemical Manipulation,' illustrated by many new and appropriate woodcuts; whilst, as the design of the book is altogether *practical*, the different processes are, as in the former edition, described in plain language and without the employment of chemical symbols and notation.

HENRY M. NOAD.

ST. GEORGE'S HOSPITAL:
February 1875.

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THE COMMERCIAL HANDBOOK

OF

CHEMICAL ANALYSIS.

ACETATE OF COPPER (Subacetate of Copper, Verdigris, Ærugo, Verditer). *See* COPPER.

ACETATE OF LEAD (Sugar of Lead, Salt of Saturn). *See* LEAD.

ACETATE OF SODIUM.—This salt is of importance as being the principal source from which acetic acid is obtained for several processes in the arts. It is sometimes contaminated by sulphate of sodium, and by chloride of sodium, or of potassium.

To detect the former, a known quantity of the salt is dissolved in water, the solution is acidified with hydrochloric acid, and then solution of chloride of barium added; the formation of a white precipitate (sulphate of barium) indicates the presence of sulphuric acid. It should be collected on a filter, washed, dried, ignited and weighed. 100 grs. sulphate of barium = 34·34 sulphuric acid = 61 sulphate of sodium.

Chloride of sodium, if present, may be detected by adding a few drops of nitric acid to a solution of a known quantity of acetate of sodium, warming the solution, and then adding solution of nitrate of silver and well agitating. The precipitate (if any) is allowed to subside, and is then collected on a small filter, washed, dried in a porcelain crucible, heated to incipient fusion and weighed. 100 grs. chloride of silver = 24·74, chlorine = 40·8 chloride of sodium.

Pure acetate of sodium is white and neutral when tried by test papers; it dissolves in 2·86 parts of cold water, and 5 parts of alcohol.

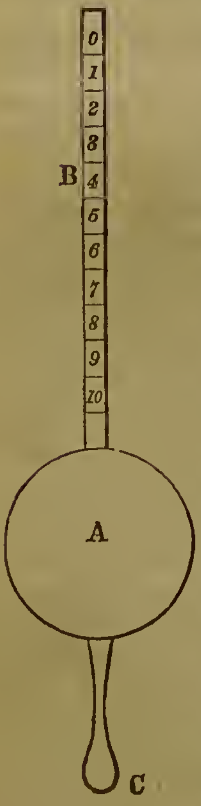
ACETIC ACID. *See* VINEGAR.

ACIDIMETRY. *See* ALKALIMETRY.

ALCOHOL (Spirit of Wine, Spirits).—The spirits of wine of commerce is essentially a mixture of alcohol and water, containing in addition a very small proportion of a peculiar oil derived from the substance from which the spirit has been obtained.

The proportion of *real* alcohol contained in spirits of wine, or its *strength*, is generally ascertained by determining its specific gravity, which is best done by weighing a known volume in a delicate balance, but more generally by an instrument called the *Hydrometer* or *Alcoholometer*, on account of the facility of its application, and of the rapidity with which the experiment can be performed. There are several forms of hydrometer, but the instrument always consists of a hollow bulb of glass or of metal, with a counterpoise below it and a slender stem above, divided into a certain number of degrees. A set of tables is generally sold with the instrument, by consulting which the specific gravity of the spirit is easily ascertained, after observing the degree upon the stem, to which the instrument sinks on being immersed in the spirit under examination.

FIG. 1.



SIKES's Hydrometer, which is the one used in levying the spirit duty in this country, is shown in the margin. It consists of a brass ball A, through which a flat stem B passes, loaded at C, and which is divided into 11 equal parts. It is also provided with nine circular weights, numbered 10, 20, 30, 40, 50, 60, 70, 80, 90, having slits by which they fit into the stem.

The instrument is adjusted so as to float with the zero of the scale, coinciding with the surface of the liquid in spirit of specific gravity 0·825 at 60° F., which is the *standard alcohol* of the Excise. In weaker spirit it will not sink so low, and if the density of the liquid be much greater it will be necessary to add one or more of the weights to cause the entire immersion of the bulb.

The sum of the number of the weights, together with the number on the scale, which is at the level of the liquid, gives, by means of a table provided for the purpose, the amount of *proof spirit* in the sample. Proof spirit being, according to Act of Parliament, such as at 51° Fahr. weighs $\frac{12}{13}$ as much as an equal bulk of water, or in other words, has a specific gravity of 0·923077 at 51°, or 0·919 at 60° F.*

---

* When spirit is said to be 30 per cent., for example, *above proof*, it is

The proportion of alcohol in spirits of wine may be expressed either by weight or by volume. Now as alcohol and water do not mix without alteration of volume, a contraction taking place varying with the temperature, the specific gravity of each mixture of alcohol and water must be determined by direct experiment. For the purposes of commerce, the amount of alcohol in spirits is estimated by volume, but for scientific purposes the strength of spirit is always expressed in percentage by weight.

The percentages of anhydrous alcohol, both by weight and volume of mixtures of alcohol and water, according to their specific gravity as determined by Tralles from the observations of Gilpin, is given in the following Table:—

Percentages of Anhydrous Alcohol by weight and volume in mixtures of Alcohol and Water.

Volumes per cent. according to Tralles	Weights per cent.	Specific gravities according to Gilpin at 60° F.	Volumes per cent. according to Tralles	Weights per cent.	Specific gravities according to Gilpin at 60° F.
0	0	1·0000	28	22·99	0·9677
1	0·80	0·9985	29	23·84	·9666
2	1·60	·9970	30	24·69	·9655
3	2·40	·9956	31	25·55	·9643
4	3·20	·9942	32	26·41	·9631
5	4·00	·9928	33	27·27	·9618
6	4·81	·9915	34	28·13	·9605
7	5·62	·9902	35	28·99	·9592
8	6·43	·9890	36	29·86	·9579
9	7·24	·9878	37	30·74	·9565
10	8·05	·9866	38	31.62	·9550
11	8·87	·9854	39	32·50	·9535
12	9·69	·9844	40	33·39	·9519
13	10·51	·9832	41	34·28	·9503
14	11·33	·9821	42	35·18	·9487
15	12·15	·9811	43	36·08	·9470
16	12·98	·9800	44	36·99	·9452
17	13·80	·9790	45	37·90	·9435
18	14·63	·9780	46	38·82	·9417
19	15·46	·9770	47	39·75	·9399
20	16·28	·9760	48	40·66	·9381
21	17·11	·9750	49	41·59	·9362
22	17·95	·9740	50	42·52	·9343
23	18·78	·9729	51	43·47	·9323
24	19·62	·9719	52	44·42	·9303
25	20·46	·9709	53	45·36	·9283
26	21·30	·9698	54	46·32	92.62
27	22·14	·9688	55	47·29	92.42

---

meant that 100 measures of this spirit, when diluted with water, would yield 130 measures of proof spirit. On the other hand, spirit 30 per cent. *below proof* contains, in 100 measures, 100 − 30, or 70 measures of proof spirit.

Percentages of Anhydrous Alcohol by weight and volume in Mixtures of Alcohol and Water—(continued).

Volumes per cent. according to Tralles	Weights per cent.	Specific gravities according to Gilpin at 60° F.	Volumes per cent. according to Tralles	Weights per cent.	Specific gravities according to Gilpin at 60° F.
56	48·26	0·9221	79	72·45	0·8664
57	49·23	·9200	80	73·59	·8639
58	50·21	·9178	81	74·74	·8611
59	51·20	·9156	82	75·91	·8583
60	52·20	·9134	83	77·09	·8555
61	53·20	·9112	84	78·29	·8526
62	54·21	·9090	85	79·50	·8496
63	55·21	·9067	86	80·71	·8466
64	56·22	·9044	87	81·94	·8436
65	57·24	·9021	88	83.19	·8405
66	59·27	·8997	89	84·46	·8373
67	59·32	·8973	90	85·75	·8340
68	60·38	·8949	91	87·09	·8306
69	61·42	·8925	92	88·37	·8272
70	62·50	·8900	93	89·71	·8237
71	63·58	·8875	94	91·07	·8201
72	64·66	·8850	95	92·46	·8164
73	65·74	·8824	96	93·89	·8125
74	66·83	·8799	97	95·34	·8084
75	67·93	·8773	98	96·84	·8041
76	69·05	·8747	99	98·39	·7995
77	70·18	·8720	100	100·00	·7946
78	71·31	·8693			

The following table by **Drinkwater** exhibits the quantities of absolute alcohol by weight, in measures of alcohol and water, of the accompanying specific gravities. It is founded on synthetic experiments, in which eleven different mixtures of alcohol and water were made, containing respectively 0·5, 1, 2, 3, 4, 5, 6, 7, 8, 9, and 10 per cent. of alcohol by weight. The alcohol employed had a specific gravity of 0·7938 at 60° F.

Absolute Alcohol by weight in measures of Alcohol and Water of different Specific Gravities.

Specific gravity at 60° F.	Alcohol by weight in 100 parts	Specific gravity at 60° F.	Alcohol by weight in 100 parts	Specific gravity at 60° F.	Alcohol by weight in 100 parts	Specific gravity at 60° F.	Alcohol by weight in 100 parts
1·0000	0·00	0·9992	0·42	0·9984	0·85	0·9976	1·29
0·9999	0·05	·9991	0·47	·9983	0·91	·9975	1·34
·9998	0·11	·9990	0·53	·9982	0·96	·9974	1·45
·9997	0·16	·9989	0·58	·9981	1·02	·9973	1·45
·9996	0·21	·9988	0·64	·9980	1·07	·9972	1·51

Absolute Alcohol by weight in measures of Alcohol and Water of different Specific Gravities—(continued).

Specific gravity at 60° F.	Alcohol by weight in 100 parts	Specific gravity at 60° F.	Alcohol by weight in 100 parts	Specific gravity at 60° F.	Alcohol by weight in 100 parts	Specific gravity at 60° F.	Alcohol by weight in 100 parts
0·9995	0·26	0·9987	0·69	0·9979	1·12	0·9971	1·56
·9994	0·32	·9986	0·74	·9978	1·18	·9970	1·61
·9993	0·37	·9985	0·80	·9977	1·23	·9969	1·67
·9968	1·73	·9934	3·67	·9901	5·70	·9868	7·92
·9967	1·78	·9933	3·73	·9900	5·77	·9867	7·99
·9966	1·83	·9932	3·78	·9899	5·83	·9866	8·06
·9965	1·89	·9931	3·84	·9898	5·89	·9865	8·13
·9964	1·94	·9930	3·90	·9897	5·96	·9864	8·20
·9963	1·99	·9929	3·96	·9896	6·02	·9863	8·27
·9962	2·05	·9928	4·02	·9895	6·09	·9862	8·34
·9961	2·11	·9927	4·08	·9894	6·15	·9861	8·41
·9960	2·17	·9926	4·14	·9893	6·22	·9860	8·48
·9959	2·22	·9925	4·20	·9892	6·29	·9859	8·55
·9958	2·28	·9924	4·27	·9891	6·35	·9858	8·62
·9957	2·34	·9923	4·33	·9890	6·42	·9857	8·70
·9956	2·39	·9922	4·39	·9889	6·49	·9856	8·77
·9955	2·45	·9921	4·45	·9888	6·55	·9855	8·84
·9954	2·51	·9920	4·51	·9887	6·62	·9854	8·91
·9953	2·57	·9919	4·57	·9886	6·69	·9853	8·98
·9952	2·62	·9918	4·64	·9885	6·75	·9852	9·05
·9951	2·68	·9917	4·70	·9884	6·82	·9851	9·12
·9950	2·74	·9916	4·76	·9883	6·89	·9850	9·20
·9949	2·79	·9915	4·82	·9882	6·95	·9849	9·27
·9948	2·85	·9914	4·88	·9881	7·02	·9848	9·34
·9947	2·91	·9913	4·94	·9880	7·09	·9847	9·41
·9946	2·97	·9912	5·01	·9879	7·16	·9846	9·49
·9945	3·02	·9911	5·07	·9878	7·23	·9845	9·56
·9944	3·08	·9910	5·13	·9877	7·30	·9844	9·63
·9943	3·14	·9909	5·20	·9876	7·37	·9843	9·70
·9942	3·20	·9908	5·26	·9875	7·43	·9842	9·78
·9941	3·26	·9907	5·32	·9874	7·50	·9841	9·85
·9940	3·32	·9906	5·39	·9873	7·57	·9840	9·92
·9939	3·37	·9905	5·45	·9872	7·64	·9839	9·99
·9938	3·43	·9904	5·51	·9871	7·71	·9838	10·07
·9937	3·49	·9903	5·58	·9870	7·78	·9837	
·9936	3·55	·9902	5·64	·9869	7·85	·9836	
·9935	3·61						

The following Table, in which the proportion of absolute alcohol by weight in 100 parts of spirits of different specific gravities at 60° F. is given, is by Fownes ('Phil. Trans.' 1847).

Every alternate number is the result of a direct synthetical experiment, absolute alcohol and distilled water being weighed out in the proper proportions, and mixed by agitation in stoppered bottles. After a lapse of three or four days, each specimen was brought exactly to 60° F., and the specific gravity determined with great care.

Absolute Alcohol by weight in 100 *parts of Spirits of different Specific Gravities.*

Alcohol per cent.	Specific gravity	Alcohol per cent.	Specific gravity	Alcohol per cent.	Specific gravity	Alcohol per cent.	Specific gravity
0.5	1·0000	25	0·9652	51	0·9160	76	0·8581
0	·9991	26	·9638	52	·9135	77	·8557
1	·9981	27	·9623	53	·9113	78	·8533
2	·9965	28	·9609	54	·9090	79	·8508
3	·9947	29	·9593	55	·9069	80	·8483
4	·9930	30	·9578	56	·9047	81	·8459
5	·9914	31	·9560	57	·9025	82	·8434
6	·9898	32	·9544	58	·9001	83	·8408
7	·9884	33	·9528	59	·8979	84	·8382
8	·9869	34	·9511	60	·8956	85	·8357
9	·9855	35	·9490	61	·8932	86	·8331
10	·9841	36	·9470	62	·8908	87	·8305
11	·9828	37	·9452	63	·8886	88	·8279
12	·9815	38	·9434	64	·8863	89	·8254
13	·9802	39	·9416	65	·8840	90	·8228
14	·9789	40	·9396	66	·8816	91	·8199
15	·9778	41	·9376	67	·8793	92	·8172
16	·9766	42	·9356	68	·8769	93	·8145
17	·9753	43	·9335	69	·8745	94	·8118
18	·9741	44	·9314	70	·8721	95	·8089
19	·9728	45	·9292	71	·8696	96	·8061
20	·9716	46	·9270	72	·8672	97	·8031
21	·9704	47	·9249	73	·8649	98	·8001
22	·9691	48	·9228	74	·8625	99	·7969
23	·9678	49	·9206	75	·8603	100	·7938
24	·9665	50	·9184				

Spirits of wine being an excisable article charged with a heavy duty proportionate to its strength, and its manufacture being fettered by very stringent regulations, it is subject to adulterations of various kinds, such as by the addition of *sugar*, or of *extractive matter*, by which its apparent strength is diminished, or by *turpentine, coal* and *wood-naphtha*, and *pyroligneous acid*, which are sometimes fraudulently added in sufficient quantity to enable the article to pass under the name of one or the other of these substances, and thus to escape the duty.

If sugar, extractive matter, or turpentine have been added, the best way of ascertaining the quantity of alcohol present consists in distilling a portion of the sample, and taking the specific gravity of the distilled portion, which, on referring to the table above, will indicate the percentage of alcohol.

The admixture of alcohol to wood-naphtha, or rather that of a small quantity of wood-naphtha, or of pyroligneous acid to a large proportion of alcohol, is a fraud which was exploded some years ago by Dr. URE, who, having examined, at the request of the Board of Customs, samples of certain parcels of goods, represented as being wood-naphtha, and which had been at first detained on suspicion, succeeded in establishing that the so-called wood-naphtha consisted almost entirely of alcohol, slightly disguised by a small proportion of pyroligneous acid.

The process recommended by Dr. Ure, for the detection of alcohol in wood-spirit, is as follows:—

'A small quantity of nitric acid, of specific gravity 1·45, is first to be added to the spirit under examination, which, if alcohol is present, will immediately produce an effervescence of nitrous ether gas, which may be recognised as such by its odour. The mixture is then treated by a solution of mercury in nitric acid (which is prepared by dissolving 100 grs. of mercury in one fluid ounce of nitric acid, with the help of heat). Soon after this addition, and especially with the help of a gentle heat, the mixture begins to effervesce and to evolve thick ethereal vapours; should the effervescence become too tumultuous or violent, it must be quelled by immediately withdrawing the fire, and cooling the vessel. A yellowish grey precipitate falls down, which is fulminate of mercury, and which should be immediately separated by decanting or filtering the liquor from it, washing the precipitate on the filter with a little distilled water, and carefully drying it at a heat which must not exceed 100° Fahr.; after which it is weighed. The quantity of fulminate of mercury obtained is nearly equal to that of the alcohol contained in the wood-spirit; at any rate, the formation of the detonating salt is quite characteristic of the presence of alcohol, since wood-spirit treated by nitric acid and mercury or silver can produce no fulminate of silver or mercury. In collecting these substances, particularly fulminate of silver, contact with anything hard should be carefully avoided, as they are dangerously explosive; fulminate of mercury explodes less readily, and should be preferred. For the purpose of collection, the feather of a quill should be used, and if the quantity is at all considerable, that is, if it exceeds a few grains, it should be collected on several filters so as to handle only small portions at a time.'

According to Ure, the best criteria for distinguishing wood-naphtha from alcohol, and ascertaining whether the former is genuine or illegally mixed with alcohol, are the following:—

First. The boiling point of pure wood-naphtha spirit is at least 20° F. below that of alcohol of the same gravity, and it exhales a characteristic pungent and offensive odour. Thus Dr. Ure found the boiling points of pure wood-spirit and of pure alcohol to be as follows:—

Sp. gr. 0·870 boiling point of wood-spirit 144° F., of alcohol 180° F.
„ 0·8832 „ „ 146° „ 171·5°

If 10 per cent. of naphtha be mixed with alcohol, the boiling point is lowered at least 6° F.

Secondly. When rectified naphtha of sp. gr. 0·870 is distilled along with a great quantity of unslaked powdered quicklime in a retort plunged in boiling water, the spirit comes over with the gravity unchanged; whereas if genuine alcohol, or a mixture of alcohol with naphtha be distilled in the same way, the distilled portion is nearly free from water, and of a gravity under 0·800, or 70 per cent. over proof, at the temperature of 60° F., wood-spirit having apparently a greater affinity for water than alcohol.

Thirdly. When water is added to alcohol the specific gravity of the liquor becomes reduced in greater proportion than when wood-spirit of the same gravity as the alcohol is diluted with the same quantity of water. Thus, for example, if alcohol of a given density is diluted with a certain quantity of water so as to bring it up to sp. gr. 0·920, wood-spirit of the same original gravity, and diluted with the same quantity of water, will become of sp. gr. 0·926 or 0·927.

According to Ure, caustic potash in powder is the most delicate test for the detection of wood-spirit in alcohol, for if wood-spirit be present the liquor assumes then a brown colour; whilst pulverized potash does not alter the colour of pure alcohol, even after several hours, and it is only after a whole day's contact that a feeble yellowish tinge is developed. But if alcohol contains only 2 per cent., or even 1 per cent. of wood-spirit, it turns yellowish in the course of ten minutes, and brown in half an hour.

The specific gravity of perfectly pure alcohol is from 0·792 to 0·800, but by mere distillation the stronger spirit does not yield alcohol of a less sp. gr. than 0·820; the alcohol of the shops never exceeds 0·835 or 0·846. *See* Brandy.

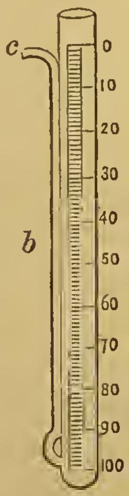
ALE. *See* Beer.

ALIZARI. *See* Madder.

ALKALIMETRY and ACIDIMETRY.—The object of alkalimetrical operations is to determine the quantity of caustic alkali or of carbonated alkali contained in the potash or soda of commerce. These operations are simple, accurate, rapid, and easy; they may be said to consist in pouring on a weighed portion of the sample of potash or of soda under examination a certain quantity of an acid of a known strength, until the alkali is saturated; that is to say, until the neutralising point is hit, which is ascertained by means of litmus paper.

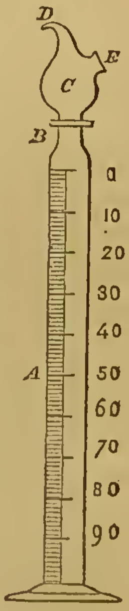
The instrument from which the name of this method of analyzing alkalies is derived, is called an *alkalimeter*. Figure 2 represents Gay-Lussac's alkalimeter; it is a glass tube about 14 inches high, and half an inch in diameter, capable of holding more than 1,000 grains of water. It is graduated accurately from the top downwards, into 100 divisions, in such a way that each division contains 10 grains of water. It has a small tube *b*, communicating with the larger one, which small tube is bent and bevelled at the top, *c*. This very ingenious instrument was contrived by Gay-Lussac, and is by far more convenient than the ordinary alkalimeter, as by it the test acid may be unerringly poured, drop by drop, as wanted. The only drawback to Gay-Lussac's alkalimeter is the fragility of the small side tube, *b*, on which account the common alkalimeter, Fig. 4 (see *infrà*), is more generally used, because, as it has no side tube, it is not liable to be so easily broken; but then it is less manageable, requires greater steadiness of hand, and does not give such accurate results, a portion of the test-acid being often wasted in various ways. Gay-Lussac's alkalimeter, therefore, is preferable; and if melted sealing wax be run, or gutta percha pressed into the interstice between the small and the large tube, the instrument is thereby rendered much less fragile.

Fig. 2.



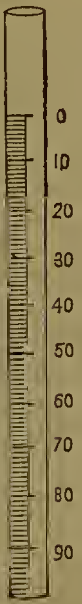
The form of alkalimeter represented in Fig. 3 is a modification of Schuster's alkalimeter, and will be found more convenient still than that of Gay-Lussac. It consists of a glass-tube, A, of the same dimensions, and graduated in the same manner as that of Gay-Lussac; but it is provided with a glass foot, and the upper part, B, is shaped like the neck of an ordinary glass bottle. C is a bulb blown from a glass tube, one end of which is ground to fit the neck, B, of the alkalimeter, like an ordinary glass stopper. This bulb is drawn to a capillary point at D, and has a somewhat large opening at E. With this instrument the acid test-liquor is perfectly under the control of the operator, for the globular joint at top enables him to see the liquor before it actually begins to drop out, and he can then regulate the pouring to the greatest nicety, whilst its more substantial form renders it much less liable to accidents than that of Gay-Lussac. The glass foot is extremely convenient, and is at the same time a great additional security.

Fig. 3.



When the common alkalimeter, Fig. 4, is used, the operator must carefully pour the acid from it, by closing the tube with his thumb, so as to allow the acid to trickle in drops as occasion may require; and it is well also to smear the lip of the tube with tallow, in order to prevent any portion of the test-acid from being wasted by running over the outside, after pouring, which accident would, of course, render the analysis altogether inaccurate and worthless; and for the same reason, after having once begun to pour the acid from the alkalimeter, by allowing it to trickle between the thumb and the lip of the tube, as above mentioned the thumb must not be removed from the tube till the end of the experiment, for otherwise the portion of acid which adheres to it would, of course, be wasted, and vitiate the result. With either of the alkalimeters, Figs. 2 and 3, this precaution is not required, the acid falling naturally, drop by drop, from the small tube, by inclining the alkalimeter.

FIG. 4.



There are several other forms of *burette* or alkalimeter. Fig. 5 is the form known as BINKS's burette. The drop tube is here at the top instead of at the bottom of the tube. The use of this instrument requires a steady hand, but after a little practice a liquid may be delivered from it with great precision.

MOHR's burette is shown in Fig. 6.

It consists of a graduated tube drawn out at the end, on which is slipped a small piece of india-rubber tubing, in the end of which is inserted a very small glass tube as a mouthpiece. The india-rubber is confined by a brass spring or pinch-cock, shown in Fig. 7. 'The advantages possessed by this instrument,' observes Mr. Sutton ('Handbook of Volumetric Analysis'), are that its constant upright position enables the operator at once to read off the number of degrees of test solution used for any analyses. The quantity of fluid delivered can be regulated to the greatest nicety by the pressure of the thumb and finger on the spring clip, or pinch-cock, and the instrument not being held in the hand, there is no chance of increasing the bulk of the fluid by the heat of the body, and thus leading to incorrect measurements, as is the case with BINKS's or GAY-LUSSAC's form of instrument.

Preparation of the Standard Acid (modification of GAY-LUSSAC's method).—Ordinary oil of vitriol is diluted with ten or twelve parts by measure of water, and allowed to cool. A quantity of the best bicarbonate of sodium is washed on a filter with cold water till the filtrate, when neutralized with pure nitric acid, ceases to give out a precipitate with either nitrate of silver or chloride of barium. It is then well dried, and heated to a low redness for some time in a porcelain or platinum crucible; when cold, it is weighed, again heated for some time, and then again weighed. The process is complete when the second atom of carbonic acid has been completely expelled, and when the weight remains constant.

FIG. 5.

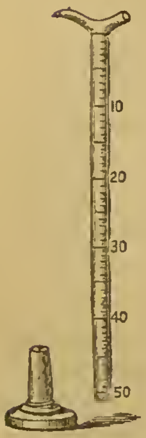


FIG. 6.

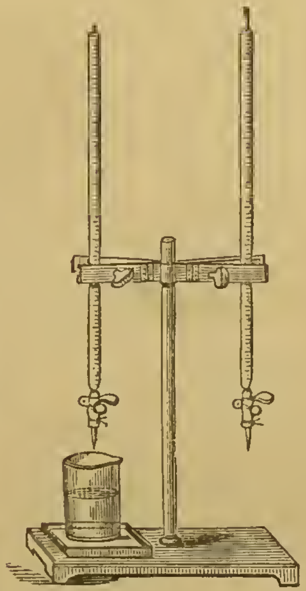
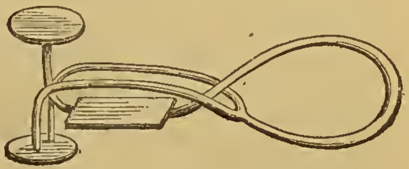


FIG. 7.



Of the purified carbonate of sodium thus prepared 530 grains are dissolved in exactly 10,000 grains of distilled water; a solution is thus obtained 1,000 grain measures of which contain 53 grains representing one equivalent of carbonate of sodium. This quantity of the alkaline solution is poured into a small beaker, and a sufficient quantity of infusion of litmus is added to communicate to it a distinct blue colour. The alkalimeter is filled exactly at 0° with the diluted acid, and a beaker being placed over a lamp (on a piece of wire gauze), the acid is poured on until the blue colour is changed to bright red. The operator must be careful not to mistake the *port-wine red* colour which the liquor assumes (from the evolution of carbonic acid) for the distinct *red* produced by a very slight addition of the acid, and when the point of saturation is approached the addition of the acid must be made with great care, the alkaline liquid being nearly boiling. The operation being finished, the quantity of acid which has been required is observed, and the experiment is repeated a second time on fresh 1,000 grain measures of the alkaline solution until perfectly concordant results are obtained.

Suppose that 600 grain measures of acid have been required to effect an exact saturation of the alkaline solution; this, then, is the quantity of acid equivalent to 53 grains of carbonate of sodium; and by adding 400 grain measures of water to every 600 grain measures of such acid, a solution is obtained, 1,000 grain measures of which, containing exactly 49 grains of mono-hydrated sulphuric acid, are equivalent to 53 grains of carbonate of sodium, to 31 grains of caustic soda, to 69 grains of carbonate of potassium, and to 47 grains of caustic potash.

Many chemists prefer *oxalic acid* to sulphuric acid, for the following reasons:—1, It is easily obtained in a state of purity by recrystallization, and in its crystalline form its composition is perfectly definite; 2, because, being a solid, it is better adapted for weighing than a liquid, and is not liable to deliquesce, or to effloresce; and 3, because it is quite *fixed* in heated solutions.

If oxalic acid be adopted as the base of the volumetric alkalimetrical system, 63 grains of the pure crystallized acid are dissolved in water, and the solution is diluted to 1,000 grain measures at 600° F. This quantity of solution will then exactly neutralize 31 grains of caustic soda, 53 grains of carbonate of sodium, 47 grains of caustic potash, and 69 grains of carbonate of potassium.

In order to control accurately this solution, MOHR tests it with a solution of caustic potash or soda; he prefers the former, as it has less action on glass. SCOTT prefers caustic soda, from the greater facility with which it may be obtained free from silicic and sulphuric acids. It is, however, immaterial which acid be employed. The caustic alkaline solution is diluted with distilled water until is exactly equal in strength to the normal acid. It is preserved in a bottle, through the stopper of which is inserted a tube containing a mixture of equal parts of sulphate of sodium and quicklime, previously mixed together, dried, and ignited.

Performance of the Alkalimetrical Assay.—a. Commerial Soda. 500 grains are weighed out from the thoroughly powdered and mixed sample. After being dried it should be gently ignited in a porcelain or platinum crucible, and allowed to cool without exposure to the air. When cool it is again weighed; the loss indicates the amount of moisture. It is then washed into a beaker, in which it is dissolved. Should any insoluble residue remain, it is filtered off, dried, and weighed; the clear filtrate is made up to exactly 10,000 grain measures. The solution is well mixed together, and from it 1,000 grain measures are taken, transferred to a beaker, the solution made blue by a few drops of litmus water, heated nearly to boiling, and then tested with the normal acid in the manner just described, until the neutral point is reached; the process may be repeated several times if necessary, to be certain of the accuracy of the analysis. In order, however, to avoid all ambiguity arising from the carbonic acid, a sufficient quantity of acid may be added to render the acid very decidedly red, and then the normal *caustic alkali* added drop by drop until the liquid changes suddenly to violet-blue. The number of divisions of the burette that have been required to effect this must be deducted from the quantity of acid originally used. By this *backward* or residual method very sharp results may be obtained.

Example.—Suppose 850 burette divisions of the normal acid have been required, the following calculation gives the amount of real carbonated alkali in the sample,

$$\text{as } 1{,}000 : 850 :: 53 : x$$

$x = 45$, the amount of carbonate of sodium in 53 grains of the sample.

The soda ash of commerce contains generally, besides insoluble substances, which are removed by filtering, a greater or less quantity of chloride of sodium (common salt) and of sulphate of sodium (which, however, do not interfere with the accuracy of the result); but when sulphurets, sulphites, or hyposulphites, are present, these substances, neutralizing a certain quantity of the test-acid, would render the estimation seriously inaccurate; wherefore it is absolutely necessary in such cases to transform these substances into sulphates by calcining a given quantity of the sample with five or six per cent. of chlorate of potassium, as recommended by GAY-LUSSAC and WELTER. The operator, therefore, should intimately mix 500 or 600 grains of pulverized chlorate of potassium with 100 grains of the pulverized sample, and fuse the mixture in a platinum crucible. The fused mass should then be dissolved in boiling water, filtered, washed, and in every respect assayed, as was described before, with one or the other of the test-acids mentioned.

But if the soda-ash contains any hyposulphite, it should not be calcined with chlorate of potassium, because under the influence of this substance one equivalent of hyposulphite becomes transformed, *not into one equivalent only of sulphate*, but, reacting upon one equivalent of carbonate of sodium, expels its carbonic acid, and forms, with the soda of the decomposed carbonate, a *second equivalent* of sulphate of sodium, each equivalent of hyposulphite becoming thus converted into two equivalents of sulphate, and therefore creating an error proportionate to the quantity of the hyposulphate present, each equivalent of which would thus destroy one equivalent of real and available alkali, and render the estimation of the sample inaccurate.

It is therefore preferable, according to Messrs. FRESENIUS and WILL, to add to the alkaline solution of the sample a small quantity of yellow chromate of potassium, the chromic acid of which transforms the sulphites, hyposulphites, and sulphurets into sulphates and water, with separation of sulphur.

Detection of Sulphuret of Sodium, Sulphite, or Hyposulphite of Sodium in Soda-ash.—Whether the sample to be analyzed contains any sulphuret of sodium, sulphite, or hyposulphite of sodium, is easily ascertained as follows:—

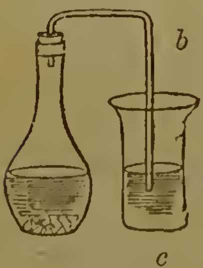
If, on pouring sulphuric acid upon a portion of the soda-ash under examination, an odour of rotten eggs (sulphuretted hydrogen) is evolved; or if a portion of the soda-ash, being dissolved in water, and then filtered, produces a black precipitate (sulphuret of lead), when solution of acetate of lead is poured into it, then the sample contains sulphuret of sodium.

And if a certain portion of the ash be added to some dilute sulphuric acid (tinged reddish-yellow by bichromate of potassium), but in quantity not sufficient to saturate the acid completely, and a *green tinge* is imparted to the acid, it is a proof that the sample contains either *sulphite* or *hyposulphite* of sodium, the green tinge being due to the transformation of the chromic acid into oxide of chromium.

If hydrochloric acid, being poured into a *clear* solution of the soda-ash and left at rest, becomes turbid after some time, and evolves an odour of sulphurous acid (the odour of burning brimstone), the turbidness is produced by a separation of sulphur, and it indicates the presence of hyposulphite of sodium.

Estimation of the Caustic Soda contained in Soda-ash.—The soda-ash of commerce frequently contains some caustic soda, the proportion of which it is sometimes important to determine. This may be done, according to M. Barreswill, by adding an excess of solution of chloride of barium to the aqueous solution of the soda-ash under examination; the carbonate of sodium is thereby converted into carbonate of barium, whilst the caustic soda, re-acting upon the chloride of barium, a quantity of free baryta is thus produced, proportionate to that of the caustic soda in the soda-ash. After this addition of chloride of barium the liquor is filtered, in order to separate the precipitated carbonate of barium produced, and which remains on the filter, on which it should be washed with pure water. A few lumps of chalk are then put into a Florence flask *a*, and some dilute hydrochloric acid being poured upon it, an effervesence due to a disengagement of carbonic acid is produced; the flask is then closed with a good cork, provided with a bent tube *b*, reaching to the bottom of the vessel *c*, and the stream of carbonic

Fig. 8.



acid produced is then passed through the liquor *c*, filtered from the carbonate of barium above-mentioned. The stream of carbonic acid produces a precipitate of carbonate of barium, which should be also collected on a separate filter, washed, dried, and weighed. Each grain of this second precipitate of carbonate of barium corresponds to 0·32 of caustic soda.

As the soda-ash of commerce almost invariably contains earthy carbonates, the sample operated upon should always be dissolved in boiling water and filtered, in order to separate the carbonate of calcium, which otherwise would in all circumstances saturate a proportionate quantity of the test acid and render the analysis worthless.

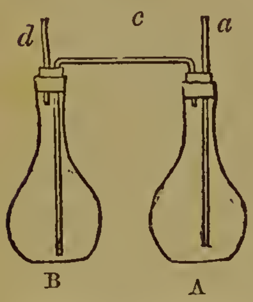
b. Commercial Pearlashes.—The mode of operating is precisely the same, but as the equivalent of carbonate of potassium is 69, the weight of the sample to be operated upon to make in solution 10,000 grain measures will be 690. It may sometimes be convenient to employ a normal sulphuric acid, 1,000 grain measures of which shall be equivalent to precisely 100 grains of the anhydrous caustic alkali. For this purpose it is obvious that different standard acids will be required for soda and for potassa. That for soda must be of such a strength that 1,000 grain measures shall saturate exactly 171 grains of pure carbonate of sodium, and that for potassa must be precisely equivalent to 146·8 grains of pure carbonate of potassium. The advantage of the standard above described is its equivalency both to potassa and soda.

Drs. Fresenius and Will's Alkalimetrical Process.—Besides the alkalimetrical processes which have been explained in the preceding pages, the proportion of available alkali contained in a sample may be estimated by ascertaining the amount of carbonic acid contained therein, and which is disengaged on neutralizing the carbonated alkali.

This method, however, of estimating the value of alkalies by the weight of the carbonic acid gas liberated, and which is always proportionate to the quantity of real alkali in the carbonate operated upon, has been long known. Dr. URE, in the 'Annals of Philosophy,' for October 1817, and afterwards in his pamphlet 'Chemistry Simplified,' described several instruments for analyzing earthy and alkaline carbonates by the quantity of carbonic acid disengaged from them when treated by an acid. The ingenious little apparatus employed by Drs. FRESENIUS and WILL for the same purpose, gives also accurate results; but it should be observed, that when the potash or soda-ash of commerce contains any caustic alkali, or bicarbonate of alkali, or any earthy or other carbonates—for example, carbonate of calcium, which is frequently the case—this process is not applicable, unless the caustic alkali or its carbonate be previously converted into the neutral carbonate; the earthy carbonate, which may be present likewise, must be removed beforehand.

The apparatus of Drs. Fresenius and Will consists of two flasks, A, B. The first must have a capacity of from two to two ounces and a half; the second, or flask B, should be of a smaller size, and hold from one ounce and a half to two ounces. Both flasks must be provided with perfectly sound corks, each perforated with two holes, through which the tubes *a*, *c*, *d*, are passing. The lower extremity of the tube *a* must be so adjusted as to reach nearly to the bottom of the flask A, and its upper extremity is closed by means of a small pellet of wax; *c* is a tube bent twice at right angles, one end of which merely protrudes through the cork into the flask A, but the other end reaches nearly to the bottom of the flask B. The tube *d* of the flask B merely protrudes through the cork into the flask.

Fig. 9.



The apparatus being disposed, a certain quantity, 100 grains for example, of the potash or soda-ash under examination (and which may have been previously dried as described above), is weighed and introduced into the flask A; water is next poured into this flask to about one-third of its capacity; concentrated sulphuric acid is now poured into the flask B, and the corks are firmly put on the flasks, which thus become connected, so as to form a twin-apparatus, which is then put on a delicate balance and accurately weighed.

The weight of the apparatus being noted down, the operator should now apply his lips to the extremity of the tube *d*, and suck out a few air-bubbles, which rarefies the air in the flask A, and consequently causes the sulphuric acid of the flask B to ascend a certain height (after the suction) into the tube *c*; and if after a short time the column of sulphuric acid maintains its height in the tube *c*, it is a proof that the apparatus is air-tight, and therefore as it should be. This being ascertained, suction is again applied to the extremity of the tube *d*, so that a portion of the sulphuric acid of the flask B ascends into the tube *c*, and presently falls into the flask A, the quantity which thus flows over being proportionate to the vacuum produced by suction. As soon as the acid comes in contact with the carbonate in the flask A, carbonic acid is disengaged, and in order to escape it must pass by the tube *c*, through the concentrated sulphuric acid of the flask B, by which it is completely dried before it finally escapes through the tube *d*. The effervescence produced by the disengagement of the carbonic acid having subsided, suction is again applied to the tube *d*, in order to cause a fresh quantity of sulphuric acid to flow over into the flask as before, and so on, until, the carbonate being completely decomposed, carbonic acid ceases to be evolved. When this point is obtained, a powerful suction is applied to the tube *d*, in order to cause a tolerably large quantity of acid to flow into the flask A, which thus becomes very hot, from the combination of the concentrated acid with the water, so that the carbonic acid is thoroughly disengaged from the solution.

When all evolution of carbonic acid gas has ceased, the little stopper of wax is carefully removed from the tube *c*, and suction applied for some time, in order to remove the carbonic acid contained in the flasks and replace it by atmospheric air. When the apparatus has become quite cold it is weighed again, the difference of weight between this second weighing and the first—that is to say, the *loss*—indicates of course the quantity of carbonic acid which was contained in the carbonate and which has escaped, from which the quantity of the carbonated alkali operated upon may be calculated. Suppose that the loss is 19½ grains, taking the equivalent of soda = 31, and that of carbonic acid = 22 (carbonate of sodium = 53), it is clear that if 22 of carbonic acid represent 31 of soda, or 53 of carbonate of sodium, the 19½ grains of carbonic acid which were disengaged represent 48 grains of carbonate of sodium, or, in other words, the 100 grains of soda-ash operated upon contained 47 per cent. of carbonate of sodium.

As the soda-ash of commerce always contains earthy carbonates, instead of putting the 100 grains which are to be analyzed directly into the flask A, it is absolutely necessary first to dissolve them in boiling water, to filter the solution, and to wash the precipitate that may be left on the filter with boiling water. The solution and the washings being mixed together, should then be concentrated by evaporation to diminish their bulk to the proper volume for introduction into the flask A, and the process is then carried on as described.

If the soda-ash under examination contain any sulphuret of sodium, sulphite or hyposulphite of sodium, it must be treated exactly as described above, previous to beginning the analysis, since otherwise sulphuretted hydrogen and sulphurous acid would be disengaged along with the carbonic acid, which would apparently augment the proportion of the latter and render the result quite erroneous.

If the soda-ash contain any caustic soda, which is frequently the case, Drs. FRESENIUS and WILL prescribe to weigh off a portion of the sample, and to triturate it in a mortar with about 3 or 4 parts of quartzose sand, and about one third part of carbonate of ammonium. The whole is then put into a small iron capsule, and the mass being moistened with aqueous ammonia is then evaporated to dryness, in order to expel the ammonia and carbonate of ammonium. The mass is then treated by water, filtered, washed, concentrated to the proper bulk by evaporation, and then treated as described.

The balance used for this mode of analysis should be capable of indicating small weights when heavily laden.

Mr. Griffin's Method of Centigrade Testing.—The unit of Mr. Griffin's system of decimal measures is called a *septem* because it contains 7 grains of pure water at the Parliamentary Standard.

100 septems = $\frac{1}{10}$ lb. of water = $\frac{1}{100}$ gallon.
1,000 septems = 1 lb. of water = $\frac{1}{10}$ gallon.
10,000 septems = 10 lbs. of water = 1 gallon.

To the measure that contains 1 lb. of water, or the tenth part of an imperial gallon, he gives the name of *Decigallon.*

The other relations are explained in the table.

Processes for Preparing Standard Solutions of Acids and Alkalies.—The rule to be followed is this: *To form a test liquor of* 5°, *which is a very convenient strength for general purposes, dissolve five test atoms* of the chemical preparation in so much water as will make a decigallon of solution at* 62° F. The practical means of weighing the test atoms and bringing them into solution are as follows :—

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* The weight of the *equivalent* of any substance taken in English grains is called a *test atom.* Thus, 56 grains is the test atom of hydrate of potash, that number representing the equivalent of hydrate of potash; and 49 grains is the test atom of sulphuric acid, that number representing the equivalent of hydrated sulphuric acid. When a test atom of any substance is dissolved in water, and the solution is further diluted with water till it occupies the bulk of a *decigallon* at 62° F., the solution is called of *one degree strength* and it is marked 1°. Hence a solution of *hydrate of potash* of 1° contains 56 grains of that salt as a *decigallon* of that solution. *Sulphuric acid* of 1° contains 49 grains of the hydrated acid in a decigallon of the diluted acid. If *five test atoms* of the dry test are contained in the same bulk of solution, its strength is called 5° (*five degrees*). It is evident from this that equal measures of solutions of the same degree are equivalent in chemical power to each other, and that any quantity by weight of test can be taken by measuring off a corresponding quantity of its solution of a known degree of strength.

Carbonate of Potassium of $2\frac{1}{2}^\circ$.—The carbonates being bibasic solutions of $2\frac{1}{2}^\circ$, are equal in saturating power to acid solutions of 5°. Ignite about 400 grains of pure carbonate of potassium for about ten minutes, then allow the crucible to cool with its cover on. When cold, weigh off 345 grains and dissolve them in a decigallon flask of water. Cover the mouth of the bottle with a piece of thin writing-paper, close it tight with the palm of the hand, and mix thoroughly. The solution thus formed will have the strength shown by No. 13 in the table on page 20, and may be used in preparing acids of 5°, with which it is equivalent measure for measure.

IMPERIAL LIQUID MEASURE.

Correspondence of the Weight and Measure of Water. Temperature, 62° *F.; Barom.,* 30 *inches; Weight, Avoirdupois.*

Gallon	Quarts	Pints	Pounds	Fluid Ounces	Cubic Inches	Fluid Drachms	Grains
1	4	8	10	160	277·274	1280	70,000
...	1	2	2·5	40	69·3185	320	17,500
...	...	1	1·25	20	34·6593	160	8750
$\frac{1}{10}$	...	...	1	16	27·7274	128	7000
$\frac{1}{70}$	...	...	$\frac{1}{7}$	2·286	3·96106	18·286	1000
$\frac{1}{100}$	...	...	$\frac{1}{10}$	1·6	2·77274	12·8	700
...	...	...	...	1	1·73296	8	437·5
...	...	...	...	·5770	1·0	4·6164	252·458
...	...	...	...	·2286	·396106	1·8286	100
...	...	...	...	·2083	·361033	1·6667	91·1458
$\frac{1}{1000}$	...	...	$\frac{1}{100}$	·16	·277274	1·28	70·0
...	...	...	...	·125	·216620	1·0	54·6875
$\frac{1}{10000}$	...	...	$\frac{1}{1000}$	·016	·027727	·128	7
...	...	...	...	·0023	·003961	·01829	1

Carbonate of Sodium of $2\frac{1}{2}^\circ$.—This is prepared in a precisely similar manner, the quantity of the pure recently ignited carbonate being 265 grains to the decigallon of water.

Sulphuric Acid of 5°.—Measure into a mixing jar 100 septems of carbonate of sodium of $2\frac{1}{2}^\circ$, and add about six drops of tincture of litmus. Fill the centigrade alkalimeter with dilute sulphuric acid (1 part strong oil of vitriol × 20 parts water). Neutralize the 100 septems of solution of carbonate of sodium, at a boiling heat, with the acid dropped in slowly from the alkalimeter till the colour changes from claret red to pale scarlet. Towards the end of the operation, after every addition of a drop of acid and agitation of the liquor, a drop of it is to be taken out on the fine point of a glass rod and applied to a piece of blue litmus paper. As soon as the alkali is perfectly neutralized, and the liquor contains the least excess of acid, the litmus paper turns red where touched with the wetted glass rod. The number of septems of the diluted acid that are required to neutralize the carbonate of sodium shows the number of septems of the acid that contain *one-tenth part of five test atoms of sulphuric acid,* or that quantity which will form 100 septems of solution of 5°. The experiment must be repeated with great care, in order to be quite certain what the number is. Suppose it to be 40 septems. In that case all that is necessary to do to produce sulphuric acid of 5° is to put 40 measures of the diluted acid into a test mixer, and add as much water as dilutes the 40 measures to 100 measures.

IMPERIAL LIQUID MEASURE,

Divided Decimally.

Gallon	Decigallons	Centigallons	Milligallons	Septems	Avoirdupois weight of Water at 62° F.	
					Grains	Pounds
1·0	10·	100·	1000·	10000·	70000·	10·
·1	1·	10·	100·	1000·	7000·	1·
·01	·1	1·	10·	100·	700·	·1
·001	·01	·1	1·	10·	70·	·01
·0001	·001	·01	·1	1·	7·	·001

1 Quart . . = 2500 Septems.
1 Pint . . = 1250 Septems.
1 Centimètre Cube = 2·2 Septems.

1 Fluid Ounce = 62·5 Septems.
1 Cubic Inch = 36·06543 Septems.
1 Litre . = 2·2 Decigallons.

Table of Test Equivalents.

		Weight of 1 Test Atom	Weight of 5 Test Atoms
1. Acetic Acid	$HC_2H_3O_2$	60·	300·
2. Hydrochloric Acid . .	HCl .	36·5	182·5
3. Nitric Acid	HNO_3 .	63·	315·
4. Oxalic Acid	HCO_2 .	45·	225·
5. Do. Crystallized . . .	HCO_2H_2O	63·	315·
6. Sulphuric Acid . . .	HSO_2 .	49·	245·
7. Tartaric Acid (Cr.) . .	$HC_2H_2O_3$	75·	375·
8. Carbonic Acid . . .	CO_2 .	44·	220·
9. Ammonia	NH_3 .	17·	85·
10. Potash Hydrate . . .	KHO .	56·	280·
11. Soda Hydrate . . .	$NaHO$.	40·	200·
12. Lime Hydrate . . .	$CaHO$.	37·	185·
13. Potassium Carbonate, 2½ atoms	K_2CO_3 .	138·	345·
14. Sodium Carbonate, 2½ atoms	Na_2CO_3 .	106·	265·

Oxalic Acid of 5°.—A test atom of crystallized oxalic acid weighs 63 grains; 5 test atoms weighs 315 grains. Take 315 grains of clean dry crystals of pure oxalic acid, and dissolve them in a decigallon of water. It has then a strength of 5°, consequently *one* measure of it will neutralize *one* measure of carbonate of sodium of $2\frac{1}{2}$°.

Solutions of Five Test Atoms in a Decigallon.

	1 Septem	2 Septs.	3 Septs.	4 Septs.	5 Septs.	6 Septs.	7 Septs.	8 Septs.	9 Septs.
1	·3	·6	·9	1·2	1·5	1·8	2·1	2·4	2·7
2	·1825	·365	·5475	·73	·9125	1·095	1·2775	1·46	1·6425
3	·315	·63	·945	1·26	1·575	1·89	2·205	2·52	2·835
4	·225	·45	·675	·9	1·126	1·35	1·575	1·8	2·025
5	·315	·63	·945	1·26	1·575	1·89	2·205	2·52	2·835
6	·245	·49	·735	·98	1·225	1·47	1·715	1·96	2.205
7	·375	·75	1·125	1·5	1·875	2·25	2·625	3·	3·375
8	·22	·44	·66	·88	1·1	1·32	1·54	1·76	1·98
9	·085	·17	·255	·34	·425	·51	·595	·68	·765
10	·28	·56	·84	1·12	1·4	1·68	1·96	2·24	2·52
11	2·	4·	6·	8·	1·	1·2	1·4	1·6	1·8
12	·185	·37	·555	·74	·925	1·11	1·295	1·48	1·665
13	·345	·69	1·035	1·38	1·725	2·07	2·415	2·76	3·105
14	·265	·53	·795	1·06	1·325	1·59	1·855	2·12	2·385

The standard solution of carbonate of sodium and of oxalic acid may be considered to be the two bases of the entire system of tests, because other alkaline and acid solutions are prepared and tested by means of these, and it is a matter of indifference which of these solutions be taken for the standard. Dr. Mohr prefers oxalic acid; Mr. Griffin prefers carbonate of sodium.

Preparation of Equivalent Test Liquors (a) Alkalies; Determination of the Chemical Strength of Liquid Ammonia.—Mix 4 septems of the ammonia to be tested with 100 septems of water and 6 drops of litmus in a wide-necked white glass bottle. Fill the centigrade test tube with sulphuric acid of 5°, and neutralize the alkali with all the precautions described above. Divide the number of septems of sulphuric acid required by 4, and then multiply by 5. The product is the chemical strength of the ammonia expressed in test atoms.

Example.—Suppose the 4 septems of ammonia to require 96 septems of acid of 5°, then 96 ÷ 4 = 24, and 24 × 5 = 120, which is the degree of the strongest commercial ammonia, the specific gravity of which is found thus:—

$$1000 - 120 = 880.$$

Having thus ascertained the *degree* of the solution of ammonia, its *atomic measure*, that is, the quantity of it which contains 1 test atom of an hydrous ammonia, is found by dividing 1000 by the number that expresses the degree. Suppose this to be 120°, then 1000 ÷ 120 = 8·33 = 41·65 septems of the strong ammonia must be diluted to 1000 septems. It is then a solution of 5°.

Caustic Potash of 5° and *Caustic Soda* of 5° are prepared in the same manner. The degree having been found by experiment, the atomic measure is calculated, and dilutions of 5 test atoms to 1000 measures is effected in the test mixer.

Acids.—*Determination of the Chemical Strength of a Sample of Nitric Acid.*—Into a flask of the capacity of 3 or 4 ounces put 100 septems of water, add 6 drops of solution of litmus, then 5 septems of the acid to be tested; shake the mixture, which will have a bright red colour. Fill the centigrade test tube with ammonia of 10° of strength, and pour drop by drop into the acid, shaking from time to time. When the brightened colour of the acid begins to appear a little fainter, the ammonia must be added in quantities of 2 drops at a time. At last the red colour is suddenly converted to blue, at which point the acid is totally neutralized.

Suppose the 5 septems of nitric acid to have required 84 septems of ammonia of 10°, then we have these calculations:

$$84 \div 5 = 16{\cdot}8 \text{ and } 16{\cdot}8 \times 10 = 168.$$

Hence the nitric acid is of the strength of 168 atoms per decigallon, or it is within 10 of the strongest possible at 62° F., as shown by table.

Preparation of Nitric Acid of 5°.—Take nitric acid of any degree of strength, and test its degree in the manner just described. Suppose the degree be found to be 165°, the atomic measure is found by dividing 1,000 by this number. Thus 1,000 ÷ 165 = 6·06. Hence 5 × 6·06; say $30\frac{1}{3}$ septems of the strong acid diluted with water in the test mixer till it forms 1,000 septems, produces nitric acid of 5°.

To Prepare Nitric Acid of 5°.—Take *ten* times 6·06 = $60\frac{2}{3}$, and dilute to 1,000 septems.

Hydrochloric Acids of 5° and 10° are prepared in exactly the same manner.

One test acid is sufficient for testing all the alkalies, and Mr. Griffin prefers sulphuric acid of 5°, though acids of 10°, 20°, 30°, may sometimes be required. The standard alkali may be either ammonia or caustic potash. A solution of ammonia of 5° can be kept a considerable time in a cool place without much alteration, but caustic potash has the advantage of not suffering loss of strength by volatilization.

When the standard test solutions are in good order, the analysis of acids and alkalis can be effected with very small quantities of liquor; 5 septems of a strong solution, or 10 septems of a weak solution, is commonly enough to operate upon. The best plan for general procedure is to begin with 5 septems and neutralize it rapidly; a rough estimate is thus got of the strength of the liquor, after which the experiment must be repeated carefully with 5 or 10 septems.

Testing of Impure Carbonate of Sodium.—The carbonate of sodium of commerce contains water and neutral salts. The object of the analysis is to find out how much carbonate of sodium it contains. Weigh out 2½ *atoms* (25 grains) and make with it a *decigallon* of solution; then measure off 100 septems, and test it with sulphuric acid of 5° in the manner described above. The number of septems of test acid used shows the percentage of pure carbonate of sodium contained in the impure sample.

Testing of Vinegar.—Take 50 septems of the vinegar, dilute with an equal bulk of pure water, add a few drops of litmus, and neutralize with test alkali of 5°. Observe the number of septems required, and divide that number by 50 and multiply it by 5, or what comes to the same thing, divide it by 10: the product is the degree of the vinegar. Suppose the number of septems to be 50, then $50 \div 50 = 1$, and $1 \times 5 = 5$, so also $50 \div 10 = 5$, which is the strength of the vinegar in test atoms per decigallon.

ALQUIFOUX (Arquifois, Potter's Ore, Galena, Sulphuret of Lead).—Alquifoux is a combination of sulphur and lead, which is used by potters to give a green varnish or enamel to pottery, on which account it is sometimes called *potter's ore.* It may be analyzed the same way as Galena. *See* LEAD.

ALUM.—The substance known as common alum is a double sulphate of aluminum and potassium; but all alums do not contain either aluminum or potassium. The word alum means in chemical language a combination of sulphate of potassium with sesquisulphate of aluminum, but the sulphate of potassium may be replaced by sulphate of sodium, or by sulphate of ammonium, and the sesquisulphate of aluminum may be replaced by sesquisulphate of iron, or of chromium or of manganese; but all alums contain the same number of atoms of water of crystallization, and they all crystallize in cubes or octohedrons.

The most important of the alums, in a technical point of view, is the potash-alum (common alum), or double sulphate of aluminum and potassium, very large quantities of which are manufactured, both in this country and abroad, for various processes in the arts. It is extensively used for dyeing, as a mordant, in the manufacture of paper, of candles, of crayons, and a variety of other purposes.

The *Roman alum* has generally a reddish colour, due to the presence of peroxide of iron, which, however, being insoluble, does not interfere with its use in dyeing.

Most of the alum used in England is extracted from aluminous schistus, containing sulphuret of iron and some bituminous matter. By exposure to the air the sulphuret of iron becomes converted into sulphate of iron, and into sulphuric acid, the consequence of which is, that the alum prepared from such materials retains traces of sulphate of iron, which render it unfit for certain dyeing operations. Even so small a trace as 0·005 interferes with the brightness of several colours.

The presence of iron is detected by dissolving a portion of the alum, and testing the solution with tincture of galls, which will then impart a black tinge to the liquor. Iron may be detected also by adding a large excess of caustic potash to the solution, and boiling the whole; the peroxide of iron will then fall down in the form of an insoluble reddish-brown precipitate.

It should be observed, that at first the addition of potash to the solution produces a bulky precipitate, because both the alumina and the peroxide of iron are thrown down; but if a sufficient quantity of solution of caustic potash be added, and the whole be boiled, the alumina is redissolved, and the insoluble portion ultimately consists of peroxide of iron only, which should be collected and thoroughly washed on a filter; after which, if the proportion obtained admits of it, it may be ignited and weighed, if need be, though for greater accuracy it is best to redissolve in muriatic acid the peroxide of iron collected on the filter, and to reprecipitate it by adding ammonia, which will then throw down the peroxide of iron only.

Lastly; the presence of iron may be detected in the solution, by testing with solution of ferrocyanuret of potassium (prussiate of potash), which, in that case, will strike a blue precipitate (Prussian blue).

Pure alum is completely soluble in water, but in different proportions according to the temperature.

According to Poggiale:—

100 parts of wator at		0° Fahr.	dissolve	3·29
”	”	50	”	9·52
”	”	86	”	22·00
”	”	140	”	31·00
”	”	158	”	90·00
”	”	212	”	357·00

A concentrated solution of alum in boiling water deposits octahedral crystals on cooling, and if these crystals are then redissolved in water at from 104° to 120° Fahr., adding potash until the precipitate at first produced by this reagent is no longer redissolved, by filtering and crystallising the filtered liquor at a gentle heat, alum is obtained in cubes free from iron and perfectly pure.

AMALGAMATED SILVER. *See* GERMAN SILVER.

AMBER (Succin).—It is now generally admitted that amber is a fossil substance of vegetable origin, formerly in the state of a balsam or resin, dissolved in a natural volatile oil, and similar to the resins which exude from several of our trees.

Amber, as found in nature, is in translucid lumps, sometimes colourless, but more generally of a light yellow, and occasionally of a dark brown or of a milk-white colour, and opaque. It is harder than all other resins, and is capable of receiving a fine polish, on which account it is often employed for ornamental purposes.

When amber is in small fragments, which is most generally the case, especially with that which is employed for making varnish, and for preparing succinic acid, it is often adulterated or mixed with small pieces of *resin*, *copal*, or *anime*. This admixture, however, may be recognised by a careful examination of the article, because the pieces of resin copal, and of resin anime, have a different appearance and fracture. The suspected pieces should be selected out, and if they be thrown upon red-hot iron it will be observed that they will not emit the peculiar odour of amber, whilst, on the other hand, the resin will fuse and fall into drops, which is not the case with amber.

AMBER-GREASE (Ambergis, Grey Amber).—Ambergris is a solid, opaque, uneven, fatty, and inflammable mass, of a light grey colour, of a darker hue externally than internally, variegated with yellow or reddish streaks.

Ambergris softens like wax by the heat of the hand, and emits a slight but agreeable odour when heated. Ambergris has scarcely any other use than in perfumery.

It is now generally admitted that this substance is a morbid concretion, analogous to the biliary calculi, formed in the stomach or intestines of the spermaceti-whale. Its composition is very simple; it consists almost entirely of a non-saponificeable grease analagous to cholesterine, and mixed with a portion of the excrements of the animal.

Great care is requisite in purchasing this substance, because it is easily imitated by a mixture of several gums and other drugs. The criterion of genuine ambergris is, that it may be easily perforated by a heated needle, and on withdrawing it, not only should the odour of ambergris be immediately evolved, but the needle should come out clean without anything whatever adhering to it.

Ambergris should be chosen in large pieces, externally of a uniform grey colour, internally of a lighter shade of grey with little black specks, and of an agreeable odour.

The specific gravity of ambergris is from 0·908 to 0·92. The analysis of ambergris gives the following results :—

Peculiar grease (ambreine)	85·
Balsamic matter, of a sweet acidulous taste, soluble in alcohol and in water, probably containing benzoic acid	2·5
Matter soluble in water, benzoic acid, and chloride of sodium	1·5

AMMONIA (Spirits of Hartshorn, Volatile Alkali, Liquor Ammoniæ).—Ammonia is a colourless gas, permanently elastic, at ordinary temperatures, very soluble in water. The usual state in which it is employed is in aqueous solution, which, when saturated, has a specific gravity of 0·875. One of the ways of ascertaining the quantity of real ammonia contained in the aqueous solution is by taking its specific gravity, either by means of the hydrometer or of the specific gravity bottle.

The following tables have been constructed, showing the amount of real ammonia contained in aqueous ammonia of different densities : —

DALTON			URE			
Specific gravity	Percentage of Ammonia	Boiling point	Specific gravity	Percentage of Ammonia	Specific gravity	Percentage of Ammonia
0·85	35·3	−4°	0·8914	27·940	0·9365	15·90
0·86	32·6	+3·5°	0·8937	27·633	0·9410	14·575
0·87	29·9	10°	0·8967	27·038	0·9545	13·250
0·88	27·3	17°	0·8983	26·751	0·9510	11·925
0·89	24·7	23·0°	0·9000	26·500	0·9564	10·600
0·90	22·2	30·0°	0·9045	25·175	0·9614	9·275
0·91	19·8	37·0°	0·9090	23·850	0·9662	7·950
0·92	17·4	44·0°	0·9133	22·525	0·9716	6·625
0·93	15·1	50·0°	0·9177	21·200	0·9768	5·500
0·94	12·8	57·0°	0·9227	19·875	0·9828	3·975
0·95	10·5	62·0°	0·9275	18·550	0·9887	2·650
0·96	8·3	70·0°	0·9320	17·225	0·9945	1·325
0·97	6·2	79·0°				
0·98	4·1	87·0°				
0·99	2·0	92·0°				

Strength of Solutions of Ammonia at 57° *F.*—(Carius.)

Ammonia in 100 parts by weight	Specific gravity	Ammonia in 100 parts by weight	Specific gravity	Ammonia in 100 parts by weight	Specific gravity	Ammonia in 100 parts by weight	Specific gravity
36	0·8844	27	0·9052	18	0·9314	9	0·9631
35	0·8864	26	0·9078	17	0·9347	8	0·9670
34	0·8885	25	0·9106	16	0·9380	7	0·9709
33	0·8901	24	0·9133	15	0·9414	6	0·9749
32	0·8929	23	0·9162	14	0·9449	5	0·9790
31	0·8953	22	0·9191	13	0·9484	4	0·9831
30	0·8976	21	0·9221	12	0·9520	3	0·9873
29	0·9001	20	0·9251	11	0·9556	2	0·9915
28	0·9026	19	0·9283	10	0·9593	1	0·9959

The real quantity of ammonia contained in its solutions can also be ascertained by its saturating power, in the manner described in the article on Alkalimetry.

Pure solution of ammonia should be as limpid as water; if it have the slightest brownish hue it is a sign of the presence of organic substances. The solution of pure ammonia should also evaporate entirely when heated, though ordinarily a small carbonaceous residue is left; but it should always be very slight.

The presence of the empyreumatic oil by which the aqueous solution of ammonia is often contaminated, may generally be detected by the odour, which may be immediately rendered perceptible by rubbing a little of the ammonia in the palm of the hand, and when evaporated, the film of empyreumatic oil which remains in the hand evolves the characteristic odour.

If the proportion of empyreumatic oil, or of organic matter, is at all considerable, its presence may also be detected by adding a large excess of concentrated sulphuric acid, which should be poured in the ammonia with great caution, and only one drop at a time. The acid, by charring the organic matter, imparts a black hue to the liquor.

The liquor ammoniæ of commerce contains sometimes *sal ammoniac*, *sulphate of ammonium*, *carbonate of ammonium*, *chloride of calcium*, and sometimes also traces of *protoxide of copper*, or of *peroxide of tin*, which may interfere with certain delicate operations. These impurities may be detected as follows:—

A certain quantity of the ammonia under examination should be first supersaturated with pure nitric acid, and a portion thereof is then tested by nitrate of silver. If a white precipitate is thereby produced, which immediately disappears on supersaturating it with ammonia, it is chloride of silver, and is a sign that the ammonia is contaminated by sal ammoniac.

If to another portion of the ammonia, supersaturated by pure nitric acid, an addition of solution of nitrate of barium produce a white precipitate, it is sulphate of barium; and, consequently, sulphuric acid or a soluble sulphate is present.

If a solution of ammonium contain *carbonate of ammonium*, which is always the case when it has been kept for some time in bottles not carefully stoppered, it is detected by pouring into it a solution of chloride of calcium, or of barium, or else lime-water, in which case a turbidness or a precipitate will be produced, owing to the formation of carbonate of calcium or of barium. If chloride of barium be used, it is of course necessary to ascertain that sulphuric acid is absent before the operator can conclude that carbonate of ammonium is present.

If the ammonia under examination contain any chloride of calcium, the addition of a solution of oxalic acid will render it turbid, or even produce a precipitate if the quantity of lime is at all large. Moreover, if a portion of the liquor of ammonia be evaporated, a residue will then be left. Pure ammonia is not rendered turbid by oxalic acid.

Traces of *oxide of copper* are at once detected by the blue colour of the ammonia liquor; if, however, the quantity of copper is too small to impart a blue colour to the liquor, its presence may be rendered apparent by adding hydrosulphuret of ammonia, which will then produce a black precipitate of sulphuret of copper.

Impure ammonia can always be purified by re-distilling it slowly.

AMMONIUM CARBONATE (Carbonate of Ammonia, Sesquicarbonate of Ammonia, Smelling-salts).—The sesquicarbonate of ammonium of commerce often contains *sal ammoniac* (*chloride of ammonium*), *sulphate of ammonium*, some *organic matter*, and also sometimes traces of *carbonate of lead*, or a *salt of calcium*.

These impurities are detected as follows:—

Pure sesquicarbonate of ammonium, being heated in a platinum crucible, should evaporate without residuum. If a carbonaceous residue is left, it is owing to the presence of organic matter; if it is fixed, it may be carbonate of lead, or a salt of calcium, which are distinguished from each other by moistening the residue with hydrosulphuret of ammonia, by which it will be blackened if lead is present; whilst it will undergo no change of colour if it consists of lime. Moreover, if the ammoniacal salt contain carbonate of lead, the latter substance will remain in an insoluble state in treating the salt with water.

If *sal ammoniac*, or any other chloride be present, the sesquicarbonate of ammonium under examination should be dissolved in water, and the solution, being tested by nitrate of silver, will then produce a white turbidness or precipitate, according to the amount of the chloride present.

If sesquicarbonate of ammonium be contaminated by *sulphate of ammonium*, an addition of nitrate of barium to the aqueous solution of the salt previously supersaturated with nitric acid, will produce a precipitate of sulphate of barium.

As these impurities exist generally in exceedingly small quantities only, their amount is best estimated by means of test-liquors of nitrate of silver, or of barium, of a known strength. The analytical process is then managed exactly as was described in the article on alkalimetry.

When sesquicarbonate of ammonium is contaminated by *empyreumatic oil*, it leaves a small carbonaceous residuum after ignition, and its solution in dilute acid is brown or even black.

As sesquicarbonate of ammonium, when left exposed to the air, becomes gradually converted into bicarbonate of ammonium, a little of the latter salt is always present.

Pure sesquicarbonate of ammonium is translucid and colourless.

AMMONIUM CHLORIDE (Sal Ammoniac, Muriate of Ammonia, Hydrochlorate of Ammonia, Chloride of Ammonium).—Sal ammoniac is met with in commerce in the shape of colourless, translucent cakes, concave on one side, and convex on the other; or in conical, crystalline, and white masses, hard and somewhat elastic, and, consequently, difficult to pulverize; this salt is inodorous, but has a bitter and acrid taste. When pure, it crystallizes from its solution in octahedral, cubic, and plumose crystals. Its specific gravity is 1·45. It is inalterable, or very slightly deliquescent in the air; soluble in three parts of cold, and in about its own weight of boiling water; it is completely soluble in alcohol. In dissolving in water it produces cold; it is fused and volatilized without decomposition by heat.

Sal ammoniac generally contains but few impurities, which consist principally of a little *sulphate of ammonium*, *chloride of sodium* (common salt), *sulphate of sodium*, and *sulphate of magnesium*. Sometimes, also, it contains some *iron* or *lead*; the first substance is derived from the volatilization of a little chloride of iron, with which it combines to form a double chloride of iron and of ammonium. The second substance (the lead) comes from the contact of the cake of sal ammoniac with the lead dome or cover, against the sides of which it gradually condenses.

Sulphate of ammonium is detected by dissolving a portion of the sal ammoniac in pure water, and testing the solution with one of chloride of barium, which, if sulphate of ammonium, or any other soluble sulphate be present, will produce a white precipitate of sulphate of barium.

The other impurities are easily detected, because they are fixed, and therefore, by heating a portion of the sal ammoniac to redness in a platinum crucible, the impurities will be left behind.

If it were desired to identify the presence of iron and of lead, it may be done by dissolving a portion of the sal ammoniac in water, and dividing it into two portions, to one of which a little nitric acid is first added; and if by pouring a drop or two of ferrocyanide of potassium, a blue precipitate is produced, it indicates the presence of iron. The presence of lead is detected by passing a current of sulphuretted hydrogen through the second portion, which produces a black precipitate of sulphuret of lead.

The aqueous solution of pure sal ammoniac should have no action whatever upon test-papers; it should not be precipitated or discoloured by either sulphuretted hydrogen or hydrosulphuret of ammonia, nor by a solution of phosphate of sodium and ammonium. It should completely volatilize by ignition, and if before the complete volatilization of the salt an abundant residuum of charcoal be observed, it is a proof of the presence of organic matter.

ANNOTTO (**Annatto, Arnotto, Rocou**).—Annotto is a colouring matter of a pasty consistence, used for dyeing silk and wool, in the preparation of certain varnishes, &c. It is prepared by macerating the pods of the *Bixa orellana* in boiling water, allowing the matter to subside, pouring the water off, and drying it in the shade. The colouring matter is sometimes mixed with oil before drying.

Annotto is met with in commerce in cakes and in rolls, hence the name of *flag* and of *cake annotto*, by which these two varieties are distinguished.

Cake annotto comes almost exclusively from Cayenne. It should be of a bright yellow colour, somewhat firm and soft to the touch.

Roll annotto comes from the Brazils, and is hard and dry, brown outside and red within; it is this species which is daily employed in England for imparting colour to cheese, in the proportion, it is said, of about 1 ounce of annotto for 1 cwt. of curds. This admixture of annotto to cheese is in no way detrimental to health, provided the drug is pure, but unfortunately it is sometimes adulterated with red lead, or with both red lead and ochre. The use of such annotto is very injurious, and serious accidents have been caused thereby. (*See* CHEESE.)

The best way of detecting the presence of lead in annotto is to heat a portion upon charcoal in the reducing flame of the blowpipe, by which means a bead of metallic lead may be obtained. The proportion of ochre present can be determined with sufficient accuracy by incinerating a given weight of the sample, washing the residuum with water, drying, and weighing.

The composition of annotto is—

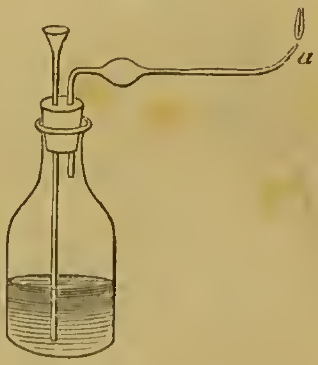
Annotto mixed with colouring matter	28
Coloured extract	20
Gum	26
Woody fibre, mixed with an acid and an aromatic substance	20
	94

ANTIMONY.—This is a brittle metal, which is easily oxidized by nitric acid, but not dissolved by it, all the degrees of oxidation of the metal being insoluble in nitric acid. The best solvent of antimony is *aqua regia*, which dissolves it completely with the aid of heat; but when it contains much lead, the solution deposits spangles.

Commercial antimony commonly contains *arsenic*, *iron*, and often small quantities of *copper* and *lead*.

Detection of Arsenic in Antimony.—One of the best methods consists in pulverizing the suspected metal, mixing it with about its own weight of tartrate of potassium, and submitting the mixture to a red heat in a covered crucible for about three hours. When cold, the crucible must be broken, and the metallic button is put in a bottle provided with a cork fitting air-tight, perforated with two holes, into one of which a small funnel is fitted; the second hole has a tube with a bulb, and is drawn to a point at *a*. Water is then poured into the bottle through the funnel, when a disengagement of hydrogen takes place, because the alloy in the bottle decomposes the water. If the antimony contained no arsenic, the hydrogen disengaged is pure; but if the least trace of arsenic is present, the hydrogen escaping at *a* has a characteristic aliaceous odour; the arsenic may be rendered visible by inflaming the gas at the point of the drawn tube *a* and depressing the flame with a china plate, or a piece of

FIG. 10.

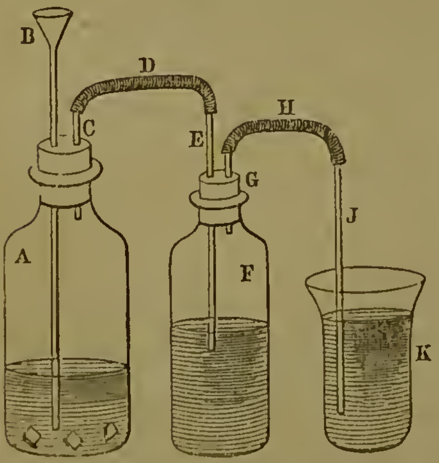


mica; spots of metallic arsenic will be observed thereon, which should be completely soluble in a solution of *chloride of lime.* The disengagement of the gas should take place under the hood of a chimney with a good draught, or in the open air, but not in the laboratory or room, arseniuretted hydrogen being an exceedingly poisonous gas.

Lead, if the antimony under examination contain any, may be easily detected by treating a given quantity of the metal, previously pulverized, by a sufficient quantity of hot nitric acid, which dissolves the lead, but leaves the antimony in a state of a white powder, which is sesquioxide of antimony. The supernatant liquor should then be carefully decanted, and the residuum being washed, dried, and ignited, may then be weighed. The filtered liquor which contains the lead in the state of nitrate, may next be evaporated to dryness; the dry residuum, being redissolved in water, must now be converted into sulphate of lead by pouring a solution of sulphate of sodium into the liquor. The white precipitate of sulphate of lead, being washed, dried, and ignited (without the filter) in a thin porcelain crucible, is then weighed—152 of sulphate of lead contain 104 of lead; or each grain of sulphate of lead contains 0·68287 of lead.

The presence of *iron* in antimony is detected by finely pulverizing a small portion of the metal, and then treating it by aqua regia, which will dissolve the whole. The solution is then diluted with a large quantity of water, which will precipitate nearly all the antimony in the shape of a bulky white precipitate, which is a basic chloride of antimony, that is, a compound of oxide and of chloride of antimony. The liquor is then filtered in order to separate the precipitate, and a current of sulphuretted hydrogen is then passed through the filtrate in order to precipitate, as sulphuret of antimony, the last portions of antimony which are contained in the clear filtrate in the state of acid chloride of that metal. The sulphuret of antimony thus produced should be separated by filtering; the filtrate should be boiled until all odour of sulphuretted hydrogen has escaped; after which the presence of iron may be detected therein by means of a solution

Fig. 11.



of ferrocyanide of potassium, which will produce a blue precipitate, or by supersaturating it with ammonia, and then adding hydrosulphuret of ammonia, which will produce a black precipitate, if iron be present. Tincture of galls may also be used as a test for iron, but the free acid should first be neutralized by ammonia or some other alkali.

The presence of sulphur may be detected by testing the solution in aqua regia, by a solution of chloride of barium, or of nitrate of barium, which will produce a white precipitate of sulphate of barium, *insoluble in water and in acids.* If the proportion of sulphur be considerable, it agglomerates in yellow lumps whilst boiling the metal in aqua regia. These yellow lumps may be readily identified as sulphur, by inflaming them upon a strip of platinum, when they will burn with a blue flame, and with the characteristic odour of sulphurous acid (the odour of burning brimstone).

Alloys of Antimony and Tin.—The separation of these metals (which, as the alloy is employed in the manufacture of a great number of utensils, may be sometimes required) is attended with difficulty.

The following method was proposed by Rose:—Strong nitric acid is cautiously poured upon the alloy, and when the violent action has ceased the whole is evaporated at a gentle heat, and the dry powder of the oxides fused in a silver crucible over an argand lamp, with an excess of hydrate of soda. The fused mass is softened with a large quantity of water, gently warmed, and the antimoniate of sodium allowed to subside. When perfectly cold, the clear solution is passed through a filter; if this be done while it is still warm, the solution will contain some antimoniate of sodium. The insoluble salt is again treated once or twice with water, allowed to settle and cool, and the liquid, when perfectly clear, passed through the filter. When the whole of the stannate of sodium has been dissolved in this manner, the liquid, which has been warmed with the antimoniate of sodium, remains opalescent; it must not be poured on the filter, as it would pass through turbid. A small quantity of a dilute solution of carbonate of sodium may be added to it, which renders it clear; but the edulcoration must not be continued for any length of time, as otherwise some antimoniate would be dissolved.

The moist antimoniate of sodium is now treated in a beaker with a mixture of hydrochloric and tartaric acids, in which it readily dissolves; and the filter, on which mere traces of the salt should have collected, is washed with the same mixture. The antimony is then precipitated from the solution by sulphuretted hydrogen, and the amount of antimony estimated from the quantity of sulphide obtained. The sulphide of antimony is reduced by hydrogen in a porcelain crucible, through the lid of which a thin porcelain tube passes. A gentle heat is carefully applied, until the crucible no longer decreases in weight. After the reduction the inner side of the lid is coated with metallic antimony, which, however, in no way interferes with the accuracy of the experiment.

The solution of stannate of sodium is acidified with hydrochloric acid. It is not necessary to add so much acid that the whole of the eliminated oxide of tin is again redissolved; it is merely necessary that the solution should strongly redden blue litmus paper. Upon this sulphuretted hydrogen is passed into it. The sulphide of tin is converted by roasting into oxide of tin. When it has been dried it frequently decrepitates, by which, if care be not taken, a very considerable loss may be occasioned. It is on this account preferred to place it with the filter, while still moist, in a porcelain crucible, and to heat it for a long time very gently, and with access of air, in order to expel the sulphur at the lowest possible temperature. If a strong heat be given at the commencement, white fumes of oxide escape, especially when the air has free access. The higher oxide of tin has the property of subliming somewhat at certain temperatures; the vapours are oxidized by contact with the air, and from oxide of tin. This is also the cause of a white sediment of oxide of tin being formed upon the charcoal when sulphide of tin is heated on charcoal before the blowpipe. A strong heat should not be applied until there is no longer a perceptible odour of sulphurous acid. After eing strongly ignited, a piece of carbonate of ammonium is placed in the crucible, and after its volatilization a strong heat applied, with access of air, in order to expel the whole of the sulphuric acid formed; a small decrease of weight will be perceived. The results do not attain the highest degree of accuracy.

Tookey finds the process of reduction by metallic iron to answer perfectly. The hydrochloric solution of the two metals is digested at a gentle heat with pure thin sheet iron, until the whole of the iron is dissolved,; a considerable quantity of cold water is then added, the antimony is collected on a weighed filter, washed, and dried; it should then be purified from traces of iron by digesting with cold dilute hydrochloric acid, dried in the water-oven, and weighed in the form of a grey powder. The tin is precipitated from the filtrate by sulphuretted hydrogen, the protosulphide of tin dried, and converted into binoxide by careful ignition.

Alloys of Antimony, Tin, and Lead.—TOOKEY avails himself of the volatility of the chlorides of tin and antimony, and the fixity of chloride of lead, to effect a separation of the metals in this alloy. For this purpose 10 grains are introduced into a bulb expanded in the middle of a piece of hard combustion-tube, having ingress and egress tubes bent at angles of 45 degrees, but in opposite directions, one pointing upwards for introducing the alloy, and the other downwards for collecting the volatile products in water. Sufficient nitric acid having been poured on the alloy, the funnel-tube is closed with a cork, and the oxidation effected at a moderate temperature. When it is converted into a perfectly white mass the excess of acid is expelled by causing a gentle current of air to traverse the apparatus, a moderate heat being at the same time applied. A current of dry hydrochloric acid gas is then transmitted slowly through the tube, the downward egress end being immersed in a small quantity of water. When the mass becomes liquid from the absorption of gas, a gentle heat is applied, the chlorides of antimony and tin distil over, and are condensed in the water, chloride of lead remaining. When the distillation is nearly finished, a greater heat is applied to expel the last traces of bichloride of tin; and lastly, the chloride of lead, now perfectly free from tin and antimony, is heated to fusion; it is then removed from the tube and converted into sulphate, in which state it is weighed. The tin and antimony in the distillate are separated by iron, as above described.

The following are the principal alloys of antimony:—

1. *Type metal*, the best description of which contains *lead* 2 parts, *tin* 1 part, *antimony* 1 part.

2. *Britannia metal*, which consists of equal parts of *brass*, *antimony*, *tin*, *bismuth*, and *lead*.

3. *Superior pewter*, consisting of *tin* 12 parts, *antimony* 1 part, and a small quantity of *copper*.

Analysis of Britannia metal.—The antimony and tin are separated as directed above; an excess of solution of carbonate of ammonium is then added to the filtrate, by which oxide of bismuth is precipitated, oxide of copper remaining in solution. The whole must be left at rest for some time in a warm place, in order that the oxide of bismuth may completely settle; it is then collected on a filter and washed with water, containing some carbonate of ammonium, until all the copper is eliminated. It is then dried, ignited, and weighed: 80 grains of oxide of bismuth contain 72 of bismuth. The excess of carbonate of ammonium should next be volatilized by evaporation, and after adding a small quantity of pure ammonia, the oxide of copper is precipitated by solution of potash, well boiled, then collected on a filter, and washed with hot water thoroughly, then dried and weighed. 100 grains of oxide of copper = 80 grains of copper.

More accurate results are obtained by first adding carbonate of sodium in slight excess to the solution, then precipitating the bismuth by heating with cyanide of potassium.

Sulphide of Antimony (*antimonium crudum; crude antimony*).—The sulphide of antimony of commerce is in masses which consist of shining crystalline needles of a deep steel grey colour, which soil paper, and which yield a black powder by trituration, in which state it is often sold. The specific gravity of sulphide of antimony is 4·5 or 4·62. Heated in the air it fuses with the greatest facility, and disengages sulphurous acid, but if heated out of the contact of the air it does not undergo decomposition. It is insoluble in water, soluble in hydrochloric acid with disengagement of sulphuretted hydrogen.

Sulphide of antimony is often contaminated by *sulphide of iron, of lead, of copper, of arsenic.*

The presence of these impurities may be detected in the following manner:—If the sample be not already in powder, it should be pulverized and boiled in aqua regia, until the sulphur separates in lumps of a perfectly yellow colour; the solution is filtered into a flask, and when cold an excess of ammonia is then added, which produces an abundant precipitate. An excess of hydrosulphuret of ammonia in maximum of sulphur (that is, hydrosulphuret of ammonia in which washed flowers of sulphur have been dissolved), is further added, and the flask being corked up, the whole is left at rest in a warm place for twelve hours. If a black residuum is left insoluble in the excess of hydrosulphuret of ammonia, the operator may conclude that the sulphide of antimony operated upon contained *iron, lead,* or other metals. If, however, copper was present, the supernatant liquor, after supersaturating with ammonia previous to the addition of the hydrosulphuret of ammonia, had a blue colour. If much *lead* were present, the solution of the sulphide of antimony must have produced a white precipitate of sulphate of lead, which will have been collected with the sulphur on the filter. The presence of lead may, however, be easily recognised by moistening the insoluble portion on the filter, and previously washed with hydrosulphuret of ammonia, which in that case will turn it black.

The sulphide of antimony which was dissolved by hydrosulphuret of ammonia may be contaminated by sulphide of arsenic, which is soluble also in that re-agent; and therefore the solution should be diluted with water, and boiled with an excess of acetic acid, which will re-precipitate both sulphides mixed with sulphur. The precipitate so produced by acetic acid should be collected on a filter, and mixed with three times its bulk of a mixture of equal parts of nitrate of potassium and of carbonate of sodium, and dried at a gentle heat. Another portion of the same mixture of nitrate of potassium and of carbonate of sodium is then to be fused in a porcelain crucible, and whilst in a state of fusion (over an argand spirit lamp, or over any gas-lamp) mixed with nitrate of potassium and carbonate of sodium, dried, and then cautiously projected in the porcelain crucible in small portions at a time. The fused mass in the crucible should then be treated by boiling water, filtered, and slightly supersaturated with nitric acid and boiled. The liquor is then tested by solution of nitrate of silver, and a small quantity of dilute ammonia is then added; if this produces a light brown precipitate, it is a basic arseniate of silver, very soluble in nitric acid and in ammonia.

The ore of sulphide of antimony, from which the crude antimony is extracted, is generally contained in a gangue or matrix of quartz, of sulphate of barium, and of iron pyrites.

A sulphide of antimony, known under the name of *glass of antimony*, is imported from Germany and Holland, which contains *silica*, and is often adulterated with *oxide of lead*. This fraud is detected by reducing the glass into fine powder, pouring nitric acid upon it, and heating the whole. The solution is then filtered, and the filtrate is tested with a solution of sulphate of sodium, which will produce a precipitate of sulphate of lead, if that metal is present. The precipitated sulphate of lead is collected on a filter, washed with water, acidified with sulphuric acid, dried, and then ignited. If no organic matter be present, and provided the filter containing the sulphate of lead has been burnt separately, and the ashes added to the sulphate of lead produced, its ignition may be performed in a platinum crucible; but if any portion of the filter is mixed with the precipitate, or if it contains any organic matter, a porcelain crucible must be used, for otherwise a portion of the sulphate of lead might be reduced to the metallic state, which would unavoidably damage the platinum crucible.

Antimony Trioxide (*antimonious acid*).—It is obtained by heating *trisulphide* of the metal with strong hydrochloric acid until sulphuretted hydrogen ceases to be evolved; the solution of trichloride thus obtained is decomposed by boiling with solution of carbonate of sodium.

When dry it is a greyish-white powder, which on heating becomes yellow, then melts into a yellowish liquid, which on cooling solidifies into a white crystalline mass. At a higher temperature it sublimes in a close vessel. When heated in the air it is partly converted into antimonic acid.

Antimonious acid dissolves in water, though very sparingly; more freely in strong *hydrochloric acid.* It is insoluble in *nitric acid* of ordinary strength, but dissolves in cold *fuming* nitric acid, the solution depositing pearly scales of nitrate; the solution, in strong hydrochloric acid, becomes turbid on the addition of water. It dissolves in boiling solution of *tartaric acid,* and very easily in a solution of *acid tartrate of potassium* (cream of tartar), forming *tartrate of antimony* and *potassium,* or *tartar emetic.*

Antimony Amorphous Trisulphide (*mineral kermes*).—Ordinary kermes, containing an admixture of antimonious oxide, is a brown red loose powder, becoming dark grey when boiled with water. It is converted by fusion into an amorphous slag-like mass. *Pure* amorphous trisulphide of antimony may be obtained by keeping the grey sulphide for some time in a state of fusion, and then cooling it very suddenly by throwing the vessel in which it has been melted into a large quantity of cold water. As thus obtained, it is a dense fissured mass, harder than the native sulphide, having a conchoidal fracture and a grey colour, or in thin pieces, dark hyacinth red, and yielding a red-brown powder, lighter in colour than the ordinary kermes.

Antimony and Potassium, Tartrate of (*tartar emetic*).—Tartar emetic crystallizes in octahedra or in tetrahedra, which are semi-transparent, colourless, slightly efflorescent, inodorous, and of a nauseous styptic taste. Exposed to heat, it blackens, is decomposed, and leaves a residuum of metallic antimony. It is soluble in fifteen parts of cold and in two parts of boiling water, but the solution is slow, especially when it is in crystals, or recently pulverised; it powerfully reddens litmus paper.

Tartar emetic is often contaminated by bitartrate of potassium (cream of tartar); the presence of this impurity may be detected by mixing together eight parts of neutral acetate of lead, fifteen parts of acetic acid, specific gravity 1·064, and thirty-two parts of water. The solution thus obtained produces a precipitate when poured in solutions of cream of tartar, but none in those of tartar emetic. Mr. Henry says that $\frac{1}{200}$th part of cream of tartar may thus be detected in tartar emetic. The precipitate requires some time to be produced.

Oxalate of ammonium may also be employed to test the purity of tartar emetic, the solution of which, if pure, is not precipitated by that salt.

The absence of cream of tartar in tartar emetic may be demonstrated by completely precipitating a solution of 20 grains of the salt by sulphuretted hydrogen gas. The weight of the precipitate thus obtained should be, when washed and collected on a tared filter, 9·91 grains.

Antimonic acid is distinguished from *antimonious acid* by its producing no precipitate with solution of *trichloride of gold*, even in the presence of excess of potash, and by its forming with nitrate of silver a *white* precipitate, perfectly soluble in ammonia. With antimonious acid the precipitate with the same reagent is *black*, and quite insoluble in ammonia.

AQUA FORTIS. *See* NITRIC ACID.

AQUILA ALBA. *See* CALOMEL.

ARGENTAN. *See* GERMAN SILVER.

ARGOL. *See* BITARTRATE OF POTASSIUM.

ARROW-ROOT.—Arrow-root is a fecula which has a great analogy with common starch and with potato-starch; but these two substances, being cheaper, are often mixed with it. This admixture, however, can be easily detected, if at all large, by an attentive examination of the sample with the naked eye, or if in less considerable quantity, with the help of the microscope.

The particles of potato-starch are of an irregular form, of various sizes, whilst arrow-root consists of particles of an even size and of an ovoid form, their surface being smooth and even. With respect to common starch, its presence may be detected because it consists of particles of a larger size and of a dull appearance when examined through the microscope, whilst the particles of arrow-root are bright, pearly, and finer. The admixture of potato-starch in arrow-root imparts to it an acrid, earthy, unpleasant flavour; but this is by no means a test to be depended upon, because badly manufactured arrow-root acquires sometimes an unpleasant flavour from the resinous matter contained in the cuticle of the plant from which it is prepared, and which no subsequent stage of the manufacture can remove. Yet as the paste which arrow-root forms with water is inodorous, whilst that made from common starch and from potato-starch has a peculiar odour, the presence of the latter may thus be generally distinguished.

The best method, however, of detecting the spurious article, consists in triturating one part of the suspected sample with 1½ or 2 parts of concentrated hydrochloric, or with dilute nitric acid of the strength of common aquafortis (specific gravity 1·10), which will immediately produce a transparent jelly, or mucilage, if flour or potato-starch be present; but if the arrow-root is pure, the mucilage produced by that treatment is white and opaque. Ground rice, however, behaves with that re-agent exactly like arrow-root, from which it can be distinguished only by the microscope, the particles of rice having a sharp, spicular, horny appearance, which can hardly be mistaken.

Potato-starch may be also easily detected by mixing the suspected arrow-root with hydrochloric acid. Genuine arrow-root so treated gives no odour whatever, but when adulterated with potato-starch an odour resembling that of beans is evolved.

ARSENIOUS ACID (Arsenic, White Arsenic, White Oxide of Arsenic).—The substance, commonly known under the name of arsenic, is arsenious acid. It is a white, nacreous, opaque, compact, brittle substance, with a conchoidal fracture, completely volatilizable by heat, but without *emitting any odour of garlic*, except it be heated in contact with charcoal or other organic matter capable of reducing it into metallic arsenic, the odour of garlic belonging to the fumes of metallic arsenic. Pulverised arsenious acid is a white powder.

Arsenious acid is most virulently poisonous; its best solvent is hydrochloric acid, but it is also sparingly soluble in water. Solutions of alkalies and of alkaline carbonates dissolve arsenious acid also.

The arsenious acid of commerce, when pulverized, is sometimes adulterated with white sand, chalk, or plaster; but these impurities are most readily detected and their proportion estimated, for arsenious acid being entirely volatilizable by heat, it is sufficient to expose a given weight of the substance to a sufficient heat (380° or 400°) in a crucible; the whole of the arsenious acid will evaporate, but the above impurities will remain behind as a fixed residuum, and may then be weighed after cooling. The volatilization of the arsenious acid in the above experiment should be carried on under the hood of a chimney with a good draught, the fumes being exceedingly poisonous.

ASA FŒTIDA.—Asa fœtida is a gum resin of a light yellow colour when fresh gathered, but which becomes brownish by keeping. It is obtained by incision from the root of a plant (*Ferula asafœtida*), found chiefly in Persia and Scinde, and the juice is inspissated.

Asa fœtida is in agglutinated more or less voluminous masses, of a brownish or drab colour variegated with white or violet specks; it has a strong and very disagreeable odour and taste resembling that of garlic. The fresher it is, the stronger are the smell and other properties of the resin, which should be chosen clean, fresh, of a strong odour, and of a reddish-brown colour. A gentle heat, even the warmth of the hand, is sufficient to soften asa fœtida, and when set fire to, it burns vividly with a pure white flame, like camphor.

This gum-resin is frequently adulterated with gums of an inferior price—with chalk, clay, sand, &c.; all these impurities may be detected by dissolving a given weight of the gum in a mixture of alcohol, and of an acid or an alkali; the impurities are then left in an insoluble state, and their amount may be determined by weighing. The insoluble portion in the genuine gum should not exceed 15 or 16 per cent. The specific gravity of asa fœtida is 1·327.

ASHES. *See* ALKALIMETRY.

AZOTIC ACID. *See* NITRIC ACID.

AZURE-BLUE. *See* SMALT.

AZURITE. *See* COPPER ORES.

BALSAM COPAIBA. *See* COPAIBA.

BARILLA. *See* ALKALIMETRY.

BASTARD SAFFRON. *See* SAFFLOWER.

BEER.—The two kinds of malt liquor consumed in this country are *Ale* and *Porter*. The former is made from the paler kinds of malt, and the fermentation of the wort is checked during the first fermentation, so as to leave a considerable quantity of saccharine matter in the liquor, which, by its subsequent conversion into alcohol and carbonic acid, tends to keep up the briskness.

Pale Ale is beer made from worts extracted from the palest malt, and boiled with the palest and best hops. The fermentation is kept at as low a temperature as possible, in order to prevent the formation of acetic acid, and the solution of the yeast by the alcohol.

Porter.—The origin of the name of this favourite beverage is thus stated by MUSPRATT ('Chemical Dictionary'):—'Previous to the year 1730 the malt liquors principally drunk in London were *ale*, *beer* and *twopenny*; and it was usual for the customers to call for half-and-half, that is, half ale and half beer, half ale and half twopenny, or half of beer and half of twopenny. In course of time it also became the practice to ask for a pint or tankard of *three threads*, signifying a third of ale, of beer, and of twopenny, and thus the publican had the trouble of going to three casks to get the mixture required. To avoid this the brewer conceived the idea of making a liquor which should unite the flavours of the three; he did so, and called it *entire*; and as it was a hearty beverage, very suitable for porters and other work-people, it was given the name of *porter*.'

The great difference between porter and common ale is derived from the variety of materials worked upon. The first employed by the porter-brewer is composed of various species of malt mixed together in different proportions.

The annexed table gives a view of these mixtures:—

Table of Porter Grists.

No.	Black	Brown	Amber	Pale	Total
1	9	0	0	91	100
2	6	34	0	60	100
3	2	30	10	58	100
4	3	25	15	57	100
5	4	24	24	48	100
6	5	0	95	0	100

Of these preference is given to the last two, as being the fittest for preparing a good porter; in the others the excess of black and brown malt occasions too much carbonaceous and useless matter in them, from which the porter acquires a disagreeable taste, as if *liquorice* and similar compounds were mixed with it. Good porter has generally the following characteristics:—it is perfectly bright, dark coloured, brisk or well impregnated with carbonic acid; light, sufficiently bitter to the taste, and free from too much acidity.

Analysis of Beer.—The normal constituents are *alcohol, carbonic acid, and extractive matters of malt and hops; acetic acid* is also present, but its amount in good beer is very small.

It is of importance to the brewer to know how to determine the composition of *genuine* beer, as it becomes a means whereby he learns the composition of the worts or *gyle* of his neighbour, and his precise method of operation. To the exporter it is of importance to know how to deduce from the results of analysis the '*original gravity*' of the wort; for by Act. 10 Vic. cap. 5 a drawback is granted of five shillings per barrel of thirty-six gallons upon beer exported, of which the worts used before fermentation are not of a less specific gravity than 1054, and not greater than 1081; and a drawback of seven and sixpence upon beer exported the worts of which before fermentation were not more than 1081 specific gravity.

Amount of Carbonic Acid in Beer.—An exact estimation of this is very rarely necessary; it does not even in bottled beer exceed 0·1 to 0·5 per cent., and of this small quantity the greater part escapes as soon as the bottle is opened. The strength of the frothing will give a very good idea of its relative amount.

Determination of the Amount of Alcohol.—The quantity of beer which is found in practice most convenient to operate upon for this purpose is *four ounces* measures; this quantity is distilled in a somewhat capacious retort combined with a LIEBIG's conductor (or more conveniently in the PHILLIPS's standard revenue still) until three-fourths of the liquid are drawn over; the distillate is then made up by distilled water to four ounces, and the specific gravity taken at the temperature of 60°. The lower the gravity the larger will be the proportion of alcohol, the percentage of which by volume and weight is shown in the following Table:—

TABLE OF

Specific Gravity and Strength of Spirits.

?

Volume per cent.	Weight per cent.	Specific gravity	Volume per cent.	Weight per cent.	Specific gravity
1·	0·80	0·99850	4·5	3·60	0·99350
1·1	0·88	0·99835	4·6	3·68	0·99336
1·2	0·96	0·99820	4·7	3·76	0·99322
1·3	1·04	0·99805	4·8	3·84	0·99308
1·4	1·12	0·99790	4·9	3·92	0·99294
1·5	1·20	0·99775	5·0	4·00	0·99280
1·6	1·28	0·99760	5·1	4·08	0·99267
1·7	1·36	0·99745	5·2	4·16	0·99254
1·8	1·44	0·99730	5·3	4·24	0·99241
1·9	1·52	0·99715	5·4	4·32	0·99228
2·0	1·60	0·99700	5·5	4·40	0·99216
2·1	1·68	0·99686	5·6	4·48	0·99202
2·2	1·76	0·99672	5·7	4·56	0·99189
2·3	1·84	0·99658	5·8	4·64	0·99176
2·4	1·92	0·99644	5·9	4·72	0·99163
2·5	2·00	0·99630	6·0	4·81	0·99150
2·6	2·08	0·99616	6·1	4·89	0·99137
2·7	2·16	0·99602	6·2	4·97	0·99124
2·8	2·24	0·99588	6·3	5·05	0·99111
2·9	2·32	0·99754	6·4	5·13	0·99098
3·0	2·40	0·99560	6·5	5·21	0·99085
3·1	2·48	0·99546	6·6	5·30	0·99072
3·2	2·56	0·99532	6·7	5·28	0·99059
3·3	2·64	0·99518	6·8	5·46	0·99046
3·4	2·72	0·99504	6·9	5·54	0·99033
3·5	2·80	0·99490	7·0	5·62	0·99020
3·6	2·88	0·99476	7·1	5·70	0·99088
3·7	2·96	0·99462	7·2	5·78	0·98996
3·8	3·04	0·99448	7·3	5·86	0·98984
3·9	3·12	0·99434	7·4	5·94	0·98972
4·0	3·20	0·99420	7·5	6·02	0·98960
4·1	3·28	0·99406	7·6	6·11	0·98949
4·2	3·36	0·99392	7·7	6·19	0·98936
4·3	3·44	0·99378	7·8	6·27	0·98924
4·4	3·52	0·99364	7·9	6·35	0·98912
			8·0	6·43	0·98900

Suppose the distillate obtained from the four ounces of beer to have a specific gravity of ·99267, then according to the Table the distillate would contain 4·08 per cent. of alcohol by weight, or 5·1 per cent. by volume.

Another method of determining the amount of alcohol in beer, which for most practical purposes is sufficiently accurate, is to calculate it from the difference between the specific gravity of the boiled and unboiled beer. The beer is first freed from carbonic acid by brisk agitation in a capacious flask, and its specific gravity accurately determined; it is then boiled briskly for some time to drive off its alcohol; the residue after cooling is diluted with water till its bulk becomes exactly equal to the original volume of the beer: it is then filtered, if necessary, through a covered filter, and its specific gravity likewise determined.

Example.—Suppose the specific gravity of the unboiled beer free from carbonic acid to be 1·0250, and, after boiling and dilution with water, to be increased to 1·0320, now as *the specific gravity of the unboiled beer is less than that of the boiled beer, in the same proportion as the specific gravity of spirit of wine of equal alcoholic strength is less than that of water*, the specific gravity of pure spirit of the same alcoholic strength as the beer will be to that of water as 1·0320; 1·0250, that is to say, it will be $\frac{1·0250}{1·0320} = 0·9932$; which, according to the Tables, corresponds to 3·76 per cent. The amount of acetic acid in beer is ascertained as follows:—An acetometer is filled to zero with the beer, which is then transferred to a test-glass. The acetometer is to be washed out with distilled water, and the washings are to be added to the beer in the test-glass; next fill the *dried* acetometer with the test ammonia solution (sp. gr. 998·6), which is to be added to the beer drop by drop, until the acid present is neutralised.

The test solution is so prepared that a given measure of it will neutralise 1 per cent. of acetic acid in an equal bulk of beer, so that if 1000 fluid grains of the solution are sufficient to neutralise the acetic acid on 1000 fluid grains of beer, such beer will contain 1 per cent. of acid, and every division of the acetometer (corresponding to 10 fluid grains) indicates ·01 per cent. of acid in the beer.

The Extractive Matter.—The amount of extractive matter is determined by evaporating a known weight of the beer in a small platinum dish, and drying the residue in an air-bath at 100°–115° C (212°–239° F), till it ceases to lose weight. As it is very hygroscopic, the dish must be weighed with its cover on, and as soon as it is sufficiently cold. This extractive matter consists mainly of *sugar*, *dextrine, albuminous matter*, and *lupulin*, the bitter principle of the hop. It is rarely necessary to submit it to analysis, but should this be required it may be roughly done in the following manner:—Dextrine and sugar may be determined by moistening the dried residue with water to a thin syrup, and gradually adding strong alcohol as long as *dextrine* is thereby separated. The clear *sugar* solution may then be decanted, and the dextrine freed from the remaining sugar by repeated solution in water and precipitation by alcohol. The precipitated dextrine and the evaporated sugar solution may then be dried and weighed. The albuminous matter may be estimated from a separate portion of the beer by boiling it so as to coagulate the albumin, collecting the precipitate on a tared filter, then washing, drying, and weighing it. Lastly, the sum of the weight of the dextrine, sugar and albuminous matter, deducted from the total weight of the extract, gives the *lupulin*.

The Mineral Constituents.—These are estimated by evaporating to dryness a known quantity of the beer, charring the residue and then igniting it in a muffle at a low red heat. They consist chiefly of *phosphates of calcium* and *magnesium; common salt*, which is sometimes added to beer, will be found in the ash. Any considerable amount of alkaline carbonate may be attributed to alkali added to neutralise the beer.

The ash of beer should be perfectly *white*; if coloured, it indicates the addition of mineral matter, which will generally prove to be sulphate of iron.

The following Tables (Watts's 'Dictionary of Chemistry') exhibit the composition of various kinds of beer and the percentage composition of the ash.

TABLE A.

Average amount of Malt Extract *and* Alcohol *in various kinds of* Beer.

Name of Beer	Percentage of	
	Malt Extract	Alcohol
London Ale (for exportation) . . .	7–5	6–8
,, Ale (ordinary)	5–4	4–5
,, Porter (for exportation) . . .	7–6	5–6
,, Porter (ordinary)	5–4	3–4
Brussels Lambik	5·5–3·5	4·5–6
,, Taro	5–3	2·5–4
Bière forte de Strasburgh	4–3·5	4–4·5
Bière blanche de Paris	8–5	3·5–4
Bavarian Beer	6·5–4	3–4·5
White Beer of Berlin	6·2–5·7	1·8–2·0

TABLE B.

Ash of Beer.

	London Beer	London Porter, 5 samples	Scotch Ale, 14 samples	Dublin Porter, 2 samples
Potash	38·35	4·9–31·1	3·2–29·8	21·4–32·0
Soda	7·68	21·8–50·8	20·9–38·5	24·0–42·7
Lime	2·45	0·8–6·9	0·2–2·0	0·8–1·5
Magnesia	3·78	0·1–1·2	0·1–5·6	0·2–1·2
Sulphuric Acid	1·36	1·6–12·2	1·6–19·2	2·8–10·1
Chlorine	2·75	6·5–14·5	4·3–18·25	6·9–10·1
Silica	9·87	8·25–19·7	4·6–19·1	6·9–19·7
Phosphoric Acid	33·76	9·3–20·6	6·0–25·7	7·9–20·0
	100·00			

TABLE C.

Special Results of the Examination of certain Beers.

Name of Beer	Malt Extract	Alcohol	Carbonic Acid	Water
London Porter (Barclay & Perkins')	6·0	5·4	0·16	88·44
„ „	6·8	6·9	not dtrmd	86·30
„ „ (Berlin)	5·9	4·7	0·37	89·00
Burton Ale	14·5	5·9	not dtrmd	79·66
Scotch Ale (Edinburgh)	10·9	8·5	0·15	80·45
Ale (Berlin)	6·3	7·6	0·17	85·93
Brussels Lambik	3·4	5·5	0·20	90·9
„ Faro	2·9	4·9	0·20	92·0
Salvator Bier (München)	9·4	4·6	0·18	85·85
Rockbier (München)	9·2	4·2	0·17	86·49
Bavarian Draught Beer	5·8	3·8	0·14	90·26
„ Store Beer, 16 months old	5·9	5·1	0·15	89·75
„ „ (München)	3·9	4·3	0·16	91·64
„ Draught Beer (Brunswick)	5·0	3·5	not dtrmd	91·10
„ Beer (Waldschlösschen)	4·9	3·6	„	91·50
Prague Draught Beer	6·9	2·4	„	90·70
„ Town Beer (Stadt-bier)	10·9	3·9	„	85·20
Sweet Beer (Brunswick)	14·6	1·36	„	84·70
Josty's Beer (Berlin)	2·6	2·6	0·5	94·30
Werder's Brown Beer (Berlin)	3·0	2·3	0·3	94·20
White Beer	5·9	1·9	0·6	91·80
Bière blanche de Louvain	3·0	4·0	not dtrmd	93·00
Petermann Louvain	4·0	6·5	„	89·50
Mum (Brunswick)	45·0	1·9	„	53·10

Determination of the Original Gravity of Beer Worts.—The specific gravity of beer is always less than that of the wort before fermentation, because by that process a portion of the sugar is converted into alcohol and carbonic acid. If, therefore, the solid matter of wort consisted entirely of sugar, there would be no difficulty in determining the 'original gravity,' since every 1 per cent. of alcohol in the beer corresponds very nearly to 2 per cent. of sugar in the unfermented wort. But as the wort contains other substances differing in specific gravity from sugar, the determination of 'original gravity' can only be effected by special methods. The subject has engaged the attention of several chemists—of Otto and Zenneck, and especially of Balling of Prague; Dobson and Phillips, of the Department of Inland Revenue; and more recently (1852) of Professors Graham, Hofmann, and Redwood, who were instructed by the Board of Inland Revenue to re-investigate and report on the matter in consequence of 'the accuracy of the means employed in the department for ascertaining the "original gravities" of beer exported on drawback having been questioned by some exporters.' The following is the substance of the elaborate Report.

The substances contained in beer wort, in addition to starch, sugar are—1st, *dextrine,* which has not been converted into sugar in the process of making. 2nd, in many cases *cane-sugar* the use of which is now permitted in breweries. 3rd, *caramel* arising either from high dried malt or from treacle or brown sugar. 4th, a peculiar saccharine substance called *extractive.* 5th, *azotised* or *albuminous* matter derived from the grain. 6th, *alkaine* and *earthy salts.*

TABLE D.

Specific Gravities of Solutions of various SACCHARINE SUBSTANCES, *and of* PALE *and* BROWN MALT *containing equal quantities of* CARBON.

Solution of Starch Sugar	Solution of Cane Sugar	Solution of Dextrine	Solution of Extractive Substance	Solution of Caramel	Solution of Pale Malt	Solution of Brown Malt	Parts of Cane Sugar corresponding in 1000 parts by weight of solution.
1010·4	1010·1	1009·7	1008·9	1008·7	1010·0	1010·0	25
1020·8	1020·2	1019·3	1017·8	1017·3	1020·3	1020·2	50
1031·3	1030·2	1028·8	1026·5	1026·2	1030·6	1030·6	75
1042·4	1040·6	1038·3	1035·5	1034·9	1041·2	1041·2	100
1053·5	1051·0	1047·9	1044·7	1043·8	1052·1	1052·0	125
1064·9	1061·8	1057·3	1053·9	1052·8	1063·0	1062·9	150
1076·9	1072·9	1066·9	1063·0	1062·2	1074·2	1074·0	175
1087·8	1083·8	1067·6	1072·7	1071·8	1085·5	1085·5	200
1099·4	1095·2	1086·3	1082·3	1081·3	1097·2	1097·2	225
1111·4	1106·7	1095·8		1091·0	1109·0	1109·0	250

Of these substances the albuminous matters and the mineral salts have but little effect on the comparative densities of the wort before and after fermentation; but the *dextrine, caramel* and *extractive matters,* all give solutions of *less* specific gravity than a solution of starch-sugar containing the same quantity of carbon, and therefore capable of yielding an equal amount of alcohol. These differences are exhibited in the following Table, from which it is seen that if an unfermented wort contain cane-sugar and dextrine, and the gravity lost by fermentation is inferred from the quantity of alcohol contained in the beer on the supposition that the fermentable matter consisted wholly of starch-sugar, the estimated gravity will be too *high*; and, on the other hand, the conversion of a portion of the fermentable sugar into unfermentable extractive matter which gives a solution of *lower* specific gravity for the same amount of carbon, will cause the estimate of the original gravity to come out too *low*; indeed the extractive substance indicates only about five-sixths of the saccharine principle from which it is derived.

To obviate these difficulties the authors of the Report were led to propose, for the determination of original gravities, a purely *empirical* method, which consisted in fermenting solutions of cane-sugar, starch-sugar, and malt-extract of known original gravity, and making, at ten or twelve stages of the process, the two following observations:— 1st. Distilling a convenient quantity (4 fluid ounces) of the fermented liquor, diluting the alcoholic distillate with water to the original volume of the liquid, and taking its specific gravity. This, deducted from the specific gravity of water = 1000, gives the *spirit indication* of the beer, *e.g.* if the specific gravity of the alcoholic distillate after dilution is 985·95, the spirit indication is 1000 − 985·95 = 14·05. 2ndly, Diluting the boiled beer after cooling to its original volume, taking its specific gravity, and subtracting this, which is called the *extract-gravity*, from the known *original gravity* of the wort before fermentation; the difference gives the number of *degrees of gravity lost*, corresponding to the spirit indication previously observed.

The results of a long series of determinations of this kind on liquids of known original gravity are given in the Report in the form of Tables, of which the two following embody the general result of the inquiry, and are intended for actual use in determining the original gravity of beer-wort.

In Table (E) the first column gives the integers of spirit indication, the practical parts (tenths) thereof being placed at the heads of the other columns; the numbers in these several columns are the degrees of gravity lost, corresponding to the several spirit indications.

Example: Suppose a sample of beer distilled as above gives a 'spirit indication' = 8·4 and an 'extract gravity' = 1022·4. On the eighth line of the Table, and in the column headed ·4 is found the number 35·9, which is the *gravity lost*; and this, added to the extract gravity, gives 35·9 + 1022·4 = 1058·3 for the original gravity of the wash.

TABLE E.

(To be used in ascertaining original gravities by the DISTILLATION PROCESS.)

Degrees of Spirit Indication with corresponding Degrees of Gravity lost in MALT WORTS.

Degrees of Spirit Indication	·0	·1	·2	·3	·4	·5	·6	·7	·8	·9
0	—	·3	·6	·9	1·2	1·5	1·8	2·1	2·4	2·7
1	3·0	3·3	3·7	4·1	4·4	4·8	5·1	5·5	5·9	6·2
2	6·6	7·0	7·4	7·8	8·2	8·6	9·0	9·4	9·8	10·2
3	10·7	11·1	11·5	12·0	12·4	12·9	13·3	13·8	14·2	14·7
4	15·1	15·5	16·0	16·4	16·8	17·3	17·7	18·2	18·6	19·1
5	19·5	19·9	20·4	20·9	21·3	21·8	22·2	22·7	23·1	23·6
6	24·1	24·6	25·0	25·5	26·0	26·4	26·9	27·4	27·8	28·3
7	28·8	29·2	29·7	30·2	30·7	31·2	31·7	32·2	32·7	33·2
8	33·7	34·3	34·8	35·4	35·9	36·5	37·0	37·5	38·0	38·6
9	39·1	39·7	40·2	40·7	41·2	41·7	42·2	42·7	43·2	43·7
10	44·2	44·7	45·1	45·6	46·0	46·5	47·0	47.5	48·0	48·5
11	49·0	49·6	50·1	50·6	51·2	51·7	52·2	52·7	53·3	53·8
12	54·3	54·9	55·4	55·9	56·4	56·9	57·4	57·9	58·4	58·9
13	59·6	60·0	60·5	61·1	61·6	62·2	62·7	63·3	63·8	64·3
14	64·8	65·4	65·9	66·5	67·1	67·6	68·2	68·7	69·3	69·9
15	70·5	—	—	—	—	—	—	—	—	—

In cases where the distillation of the beer is troublesome, the original gravity may be arrived at in another way, viz. :—The specific gravity of the beer, deprived by agitation of carbonic acid, is first taken. It is then boiled in a flask till the alcohol is expelled, then diluted to its original volume, and the specific gravity again taken. The first result, the *beer gravity*, deducted from the second, the extract gravity, is spirit indication: thus if beer, before boiling, has a specific gravity of 1035·1, and after boiling of 1044·7, the spirit indication is 1044·7 − 1035·1 = 9·6 degrees.

By numerous experiments, in which the beer was boiled in a retort, and the alcoholic distillate collected as above, it was found that the *evaporation method* (the second) gave a spirit indication nearly equal to that resulting from the first, or distillation method, but always sensibly *less*. Thus the spirit indication of a particular sample was by the first method 9·9 degrees, and by the second method 9·6 degrees. These experiments were made in liquids of known original gravity, and thus a series of determinations were obtained of the *relation between* the spirit indication as determined by the *evaporation method,* and the degrees of gravity lost. The general result of the inquiry, as applied to malt worts, are given in Table (D).

TABLE F.

(To be used in ascertaining original gravities by the EVAPORATION PROCESS.)

Degrees of Spirit-indication with corresponding Degrees of Gravity lost in MALT WORTS.

Degrees of Spirit Indication	·0	·1	·2	·3	·4	·5	·6	·7	·8	·9
0	—	·3	·7	1·0	1·4	1·7	2·1	2·4	2·8	3·1
1	3·5	3·8	4·2	4·6	5·0	5·4	5·8	6·2	6·6	7·0
2	7·4	7·8	8·2	8·7	9·1	9·5	9·9	10·3	10·7	11·1
3	11·5	11·9	12·4	12·8	13·2	13·6	14·0	14·4	14·8	15·3
4	15·8	16·2	16·6	17·0	17·4	17·9	18·4	18·8	19·3	19·8
5	20·3	20·7	21·2	21·6	22·1	22·5	23·0	23·4	23·9	24·3
6	24·8	25·2	25·6	26·1	26·6	27·0	27·5	28·6	28·5	29·0
7	29·5	30·0	30·4	30·9	31·3	31·8	32·3	32·8	33·3	33·8
8	34·3	34·9	35·5	36·0	36·6	37·1	37·7	38·3	38·8	39·4
9	40·0	40·5	41·0	41·5	42·0	42·5	43·0	43·5	44·0	44·4
10	44·9	45·4	46·0	46·5	47·1	47·6	48·2	48·7	49·3	49·8
11	50·3	50·9	51·4	51·9	52·5	53·0	53·5	54·0	54·5	55·0
12	55·6	56·2	56·7	57·3	57·8	58·3	58·9	59·4	59·9	60·5
13	61·0	61·6	62·1	62·7	63·2	63·8	64·3	64·9	65·4	66·0
14	66·5	67·0	67·6	68·1	68·7	69·2	69·8	70·4	70·9	71·4
15	72·0	—	—	—	—	—	—	—	—	—

The want of coincidence between the two sets of Tables is thus explained. The same degrees of gravity lost give less spirit, or, in other words, the same spirit or degrees of spirit indication always give *more* degrees of gravity lost in the *Evaporation Tables* principally from this circumstance. When alcohol is added to pure water, the density of the latter undergoes a certain diminution. By an addition of 8 per cent. by weight of alcohol, the density of water is reduced from 1000 to 986·7, which is a loss of gravity of 13·3 degrees. But 8 per cent. of alcohol in the same volume as before of water containing 10 per cent. of cane-sugar occasions a loss of gravity of only 12·92° (a fall from 1036·47 to 1023·55). The degrees of spirit indication obtained are therefore *less* from the same absolute quantity of spirit in the sugar solution than in pure water. Now the sugar solution containing alcohol *represents beer,* and gives the loss of gravity which the beer sustains by evaporation. On the other hand, the first mixture of pure water and alcohol represents the dilute spirits obtained from the same beer by distillation. Thus the results, according to the Tables, would be—

Degrees of spirit indication .	13·30	by *distillation*
" " " . .	12·92	by *evaporation*
Difference . . .	0·38	

It thus appears that alcohol reduces the gravity of a solution of sugar (or we may suppose infusion of malt) not quite so much (by a small quantity) as it reduces the gravity of water. It has been believed that alcohol has the same effect upon the density of saccharine solution as upon water, in which case the spirit indications obtained by beer by the *evaporation* and *distillation* methods should necessarily be the same, but from a series of experiments made by the authors of the Report on the subject, it appears that a sensibly greater condensation always occurs when spirits are mixed with saccharine solutions than with water.

Notwithstanding, then, that the *evaporation process* is the easiest in practice, it does not appear to admit of the same degree of precision as the *distillation process.*

Table G.

For ascertaining the Value of the Acetic Acid.

Excess per cent. of Acetic Acid in the Beer.	Corresponding Degrees of Spirit Indication.									
	·00	·01	·02	·03	·04	·05	.06	·07	·08	·09
·0	—	·02	·04	·06	·07	·08	·09	·11	·12	·13
·1	·14	·15	·17	·18	·19	·21	·22	·23	·24	·26
·2	·27	·28	·29	·31	·32	·33	·34	·35	·37	·38
·3	·39	·40	·42	·43	·44	·46	·47	·48	·49	·51
·4	·52	·53	·55	·56	·57	·59	·60	·61	·62	·64
·5	·65	·66	·67	·69	·70	·71	·72	·73	·75	·76
·6	·77	·78	·80	·81	·82	·84	·85	·86	·87	·89
·7	·90	·91	·93	·94	·95	·97	·98	·99	1·00	1·02
·8	1·03	1·04	1·05	1·07	1·08	1·09	1·10	1·11	1·13	1·14
·9	1·15	1·16	1·18	1·19	1·21	1·22	1·23	1·25	1·26	1·28
1·0	1·29	1·31	1·33	1·35	1·36	1·37	1·38	1·40	1·41	1·42

Influence of Acetic Acid on original Gravity.—In the examination of fermented liquids the *acetic* acid present should not be overlooked, as the influence of this constituent upon the original gravity of some kinds of beer, particularly old and hard beer, is often considerable. There is, however, a certain amount of acid present in all healthy fermentation; and this, in the experiments on which the above Tables have been founded, was estimated as one part of *absolute acetic acid in one thousand parts of wort.* Any excess of acid beyond this should be ascertained by neutralising the beer by an alkaline solution. Sixty parts (one equivalent) of acetic acid represents forty-six parts of absolute alcohol—a proportion by which the weight of alcohol which has disappeared in the formation of acetic acid is calculated.

This corresponding weight of alcohol has a certain *spirit indication*, which is to be added to the spirit indication of the beer itself, before the degrees of gravity-test are taken from the Table. The calculated original gravity of *old* beer is often thus very sensibly increased. The addition to be made to the actual degrees of spirit indication, as found by weighing the distillate for any excess of acetic acid above 0·1 per cent., is shown in Table G.

As an example of the distillation process, suppose the results of the examination of a sample of beer to be—

Specific gravity of Beer	1006·4
" Spirit	992·1
" Extract	1014·1;

and suppose that in neutralising the acid in 1000 fluid grains of a beer, 46 divisions of the acetometer were emptied, or that 460 fluid grains of the ammonia solution were required, the beer would then contain 0·46 per cent. of acetic acid; then

Acetic acid present	0·46 per cent.
Deduct as being allowed for in the Table	0·10 „
Acetic acid to be taken account of . .	0·36
Degrees of 'spirit indication,' or 1000 *minus* the sp. gr. of the distillate	7·9
Add for 0·36 per cent. of acetic acid, as by the above Table	0·47
True spirit indication	8·37

Then by Table E 8·37° of spirit indication correspond to 35·73° of gravity lost, or

Sp. Ind.	Gravity.
8.37 correspond to	35·75
Add gravity of extract	1014·10
Original gravity of beer . . .	1049·85

Throughout the process, care must be taken that the liquids are measured and weighed at the temperature of 60° Fahr.; that before being poured into the weighing-bottle they are agitated, and that the bottle when filled be free from air-bubbles.

The practice of the Revenue is to recognise no expression for the 'original gravity' of beer other than that of the true specific gravity of the wort at 60° Fahr., or the weight of 1000 fluid grains at that temperature, whilst that adopted by brewers is different, the density of worts being expressed by them at so many 'lbs. per barrel.'

The following Table will show the relations between the two forms of expression ($\frac{36}{100}$ths of a lb. per barrel correspond to 1 degree of gravity, or 1 lb. per barrel corresponding to 2 degrees and the $\frac{7}{9}$ths of a degree of gravity):—

TABLE H.

Showing the Specific Gravity of Worts at a Temperature of 60° F., and the corresponding 'lbs. per Barrel' as determined by Brewers.

Specific Gravity or 'Original Gravity'	lbs. per Barrel of 36 Imperial Gallons	Specific Gravity or 'Original Gravity'	lbs. per Barrel of 36 Imperial Gallons	Specific Gravity or 'Original Gravity'	lbs. per Barrel of 36 Imperial Gallons	Specific Gravity or 'Original Gravity'	lbs. per Barrel of 36 Imperial Gallons	Specific Gravity or 'Original Gravity'	lbs. per Barrel of 36 Imperial Gallons
1001	0·36	1031	11·16	1061	21·96	1091	32·76	1121	43·56
1002	0·72	1032	11·52	1062	22·32	1092	33·12	1122	43·92
1003	1·08	1033	11·88	1063	22·68	1093	33·48	1123	44·28
1004	1·44	1034	12·24	1064	23·04	1094	33·84	1124	44·64
1005	1·80	1035	12·60	1065	23·40	1095	34·20	1125	45·00
1006	2·16	1036	12·96	1066	23·76	1096	34·56	1126	45·36
1007	2·52	1037	13·32	1067	24·12	1097	34·92	1127	45·72
1008	2·88	1038	13·68	1068	24·48	1098	35·28	1128	46·08
1009	3·24	1039	14·04	1069	24·84	1099	35·64	1129	46·45
1010	3·60	1040	14·40	1070	25·20	1100	36·00	1130	46·80
1011	3·96	1041	14·76	1071	25·56	1101	36·36	1131	47·16
1012	4·32	1042	15·12	1072	25·92	1102	36·72	1132	47·52
1013	4·68	1043	15·48	1073	26·28	1103	37·08	1133	47·88
1014	5·04	1044	15·84	1074	26·64	1104	37·44	1134	48·24
1015	5·40	1045	16·20	1075	27·00	1105	37·80	1135	48·60
1016	5·76	1046	16·56	1076	27·36	1106	38·16	1136	48·96
1017	6·12	1047	16·92	1077	27·72	1107	38·52	1137	49·32
1018	6·48	1048	17·28	1078	28·08	1108	38·88	1138	49·68
1019	7·20	1049	17·64	1079	28·44	1109	39·24	1139	50·04
1020	7·30	1050	18·00	1080	28·80	1110	39·60	1140	50·40
1021	7·56	1051	18·36	1081	29·16	1111	39·96	1141	50·76
1022	7·92	1052	18·72	1082	29·52	1112	40·32	1142	51·12
1023	8·28	1053	19·08	1083	29·88	1113	40·68	1143	51·48
1024	8·64	1054	19·44	1084	30·24	1114	41·04	1144	51·84
1025	9·00	1055	19·80	1085	30·60	1115	41·40	1145	52·20
1026	9·36	1056	20·16	1086	30·96	1116	41·76	1146	52·56
1027	9·72	1057	20·52	1087	31·32	1117	42·12	1147	52·92
1028	10·08	1058	20·88	1088	31·68	1118	42·48	1148	53·28
1029	10·44	1059	21·24	1089	32·04	1119	42·84	1149	53·64
1030	10·80	1060	21·60	1090	32·40	1120	43·20	1150	54·00

Adulteration of Beer.—Dr. Ure says, in his 'Dictionary of Chemistry' (4th edition, 1831, p. 203):—

'As long ago as the reign of Queen Anne brewers were forbidden to mix *sugar, honey, Guinea-pepper, essentia bina, cocculus indicus*, or any other unwholesome ingredient, in beer under a certain penalty; from which we may infer that such at least was the practice of some; and writers who profess to discuss the secrets of the trade mention most of these and some other articles as essentially necessary. The *essentia bina* is sugar boiled down to a dark colour and empyreumatic flavour. *Broom-tops, wormwood*, and other bitter plants, were formerly used to render beer fit for keeping before hops were introduced into this country, but are now prohibited to be used in beer made for sale.'

'By the present law of this country, nothing is allowed to enter into the composition of beer except malt and hops. *Quassia* and *wormwood* are sometimes fraudulently introduced, both of which are easily discoverable by their nauseous bitter taste. They form a beer which does not preserve so well as hop beer. *Sulphate of iron, alum*, and *salt*, are often added by the publicans under the name of *beer-heading*, to impart a frothy property to beer, when it is poured out of one vessel into another. *Molasses* and extract of *gentian root* are added with the same view. *Capsicum, grains of paradise, ginger-root, coriander-seed*, and *orange-peel*, are also employed to give pungency and flavour to weak or bad beer. The following is a list of some of the unlawful substances seized at different breweries, and brewers' druggists' laboratories in London, as copied from the Minutes of a Committee of the House of Commons:—*cocculus indicus, multum* (an extract of the cocculus), *colouring honey, hartshorn-shavings, Spanish juice, orange-powder, ginger, grains of paradise, quassia, liquorice, carraway-seeds, copperas, capsicum, mixed drugs.*

'*Sulphuric acid* is frequently added to *bring beer forward*, or make it hard, giving to new beer instantly the taste of what is eighteen months old.'

The Act 56 Geo. III., cap. 58, stipulates that 'No brewer, or dealer, or retailer of beer, shall receive, or have in his possession, or make, or use, or mix with, or put into worts or beer, any liquor, extract, calx, or other material or preparation for the purpose of darkening the colour of worts or beer, or any liquor, extract, calx, or other material or preparation other than brown malt, ground or unground as commonly used in brewing; or shall receive or have in his possession, or use, or mix with, or put into any worts or beer, any *molasses, honey, liquorice, vitriol, quassia, cocculus indicus, grains of paradise, Guinea-pepper*, or *opium*, or *any extract or pre-*

paration of molasses, honey, liquorice, vitriol, quassia, cocculus indicus, grains of paradise, Guinea-pepper, or *opium,* or *any article or preparation whatsoever* for, *or as a substitute* for malt and hops, upon pain that all such liquor, extract, calx, molasses, honey, vitriol, quassia, cocculus indicus, grains of paradise, Guinea-pepper, opium, extract, article and preparation as aforesaid, and also the said worts and beer, shall be forfeited, together with the casks, vessels, and other packages, and may be seized by any officer of excise; and such brewer of, dealer in, or retailer of beer so offending shall for each offence forfeit 200*l.*

'No druggist, or vendor of, or dealer in drugs, or chemist, or other person whatever, shall sell, send, or deliver to any licensed brewer of, or dealer in, or retailer of beer, knowing him to be so licensed, or reputed to be so licensed, or to any other person, for, or on account of, or in trust for, or for the use of such brewer, dealer, or retailer, any colouring from whatever material made, or any other material or preparation, other than unground brown malt, for the purpose of darkening the colour of worts or beer, or any liquor or preparation heretofore or hereafter made use of for darkening the colour of worts or beer, or any molasses, or other articles, as mentioned in the first section, for, or as a substitute for malt or hops respectively; and if any druggist, or vendor of, or dealer in drugs, or any chemist, or other person whatever shall so do; all such liquor called colouring, and material or preparation for the purpose aforesaid, and liquor and preparation used for darkening the colour of worts or beer, molasses, and article or preparation to be used as a substitute for malt or hops, shall be forfeited, and may be seized by any officer of excise, and the druggist, vendor, dealer, chemist, or other person so offending shall forfeit 500*l.*'

By the Act 1 Will. IV. c. 51, for the repeal of the ale and beer duties, it is enacted, § 17: 'That no brewer shall have in his brewery, or in any part of his entered premises, or in any mill connected with such brewery, any raw or unmalted corn or grain; and all unmalted corn or grain which shall be found in such brewing premises or mill, and all malted corn or grain with which such unmalted corn or grain may have been mixed, shall be forfeited, and may be seized by an officer, with all vessels or packages in which such raw or unmalted corn or grain shall be contained, or in which such unmalted corn or grain, and the malted corn or grain with which the same may have been mixed shall be contained; and every brewer shall for every such offence forfeit 200*l.*'

Most of the substances enumerated above are perfectly harmless; two, however, are particularly objectionable, viz. *picric acid* and *cocculus indicus*, especially the latter, which contains a very poisonous substance, viz. *picrotoxin*.

With regard to *burnt sugar* or *treacle*, which are sometimes added to porter to give it colour and body, their use is now legalized, and they can therefore no longer be regarded as adulterations.

Picric Acid.—This adulteration may, according to LASSAIGNE, be detected thus:—The beer is to be agitated with a solution of subacetate of lead in excess. This throws down a precipitate consisting of the bitter and most of the colouring matter of the hop; whilst picric acid, if present, is unaffected by this re-agent, and therefore remains, communicating its peculiar taste to the liquid. Another test is to treat the beer, evaporated to half or a quarter of its bulk, with subacetate of lead, or to shake it up with powdered animal charcoal. Pure beer is thereby almost wholly discoloured; but if picric acid is present, the filtered liquid retains its yellow colour. This reaction is very delicate, sufficing to detect 1 part of picric acid in 12,000 or 18,000 parts of beer. According to POHL, a still more delicate test for picric acid is obtained by immersing unbleached sheeps' wool, or any fabric made therewith, in the beer, boiling for six or ten minutes, and then washing the wool. If the beer is pure, the wool remains white; but if picric acid is present, even to the amount of only 1 part in 125,000, the wool then appears of a canary yellow colour, pale or dull according to the quantity.

Cocculus Indicus.—T. J. HERAPATH'S test for the detection of the active principle of this substance is based upon the property which charcoal possesses of separating *picrotoxin* from its aqueous solution. An excess of acetate of lead is added to the beer in order to throw down the humulin and other extractive matters; the precipitate is removed by filtration, and the excess of lead in the filtrate removed by sulphuretted hydrogen. After filtration the solution is boiled, then slowly evaporated until the residue assumes a thick consistency, and a small quantity of pure animal charcoal agitated with it for a few minutes.

When cool the solution is filtered, and the charcoal containing the *picrotoxin* washed with the smallest quantity of water, then dried at 212° F. After all the moisture has been expelled, the charcoal is boiled with some pure alcohol to dissolve the alkaloid, the solution is filtered and evaporated, and the picrotoxin permitted to crystallize spontaneously. If present in large quantities, it is deposited in fine well-formed prisms; if in small quantity, only in long radiating needles.

Mineral Adulterations.—Should these be suspected, their presence may be proved by evaporating the beer to dryness, and incinerating the residue in a platinum capsule or basin, till the whole of the organic matter is destroyed, then dissolving the ash in as small a quantity of hydrochloric acid as possible, and testing—for iron with sulphocyanide of potassium, which will give a blood red coloration if that metal be present—for lime by the addition of ammonia and oxalate of ammonium, which will cause a white precipitate. Should common salt be suspected, it may be proved by dissolving a portion of the ash in water, filtering, and adding nitric acid and nitrate of silver; from the bulk of the precipitated chloride of silver the presence or absence of salt is inferred. Some chlorides are naturally present, so that the formation of a slight opalescence does not prove the adulteration. Should *alum* be present, it will precipitate in the form of white flocculi on adding ammonia to the solution when testing for lime.

BEESWAX. *See* WAX.

BELL METAL. *See* BRONZE.

BENJAMIN. *See* BENZOIN.

BENZOIN (Benjamin, Frankincense).—Benzoin is a resin extracted by incision from a tree (*Styrax benzoin*), and is met with in commerce in large, irregular, brittle lumps; its fracture offers a mixture of white, red, and brown veins or spots of various sizes; but the worst quality, called *foot*, is almost exclusively brown, and full of vegetable stalks, sand, and other impurities.

The best quality, when broken, has the appearance of white marble, but is seldom met with.

The value of the article may be estimated from the quantity of benzoic acid obtained.

Good benzoin contains from 15 to 18 per cent. of benzoic acid, which, according to STOLTZE, may be extracted as follows:—

Dissolve a given weight of the resin in three parts in weight of alcohol, pour the solution into a retort, and add thereto a solution of carbonate of sodium in eight parts of water, with three parts of alcohol, until the alcoholic solution of the benzoin is exactly neutralized; that is, until it ceases to have an acid reaction, which is known when it begins to turn reddened litmus paper blue. A quantity of water, equal to double the weight of the resin operated upon, is then added to the liquor, the alcohol is distilled off, and the liquor which remains in the retort contains the benzoic acid and the resin. The latter is removed by decanting the liquor, and washed; on weighing it, it is found to be equal to 80 or 82 per cent. of the benzoin employed, if pure. The liquor decanted from the resin is then treated by dilute sulphuric acid, in order to precipitate the benzoic acid, which may be collected on a filter, well washed with cold water, and weighed.

But the value of benzoin may also be ascertained by the quantity of benzoic acid obtained from it by sublimation. Several processes may be employed, but that described by M. HATCHETT is perhaps the most easy. It consists in digesting a given weight of the benzoin in sulphuric acid, and then, by applying heat, a sublimate of benzoic acid is obtained.

BENZOIC ACID (Flowers of Benzoin).—Pure Benzoic acid is white, but it often has a brownish tinge, owing to the presence of a certain quantity of resin, which sometimes is considerable. Pure benzoic acid is odourless, but it generally has a slight odour of incense or of vanilla, especially when it has been obtained by sublimation, which is generally the case. It should volatilize completely when heated, and be entirely soluble in alcohol, and likewise in boiling water; but the latter solution on cooling stiffens into a solid mass, because the acid is only sparingly soluble in cold water. Benzoic acid is also dissolved by a solution of potash and by lime water, from which solutions it may be immediately reprecipitated by an addition of muriatic acid. These reactions are peculiar, and enable the operator to separate easily any impurities or admixtures which may contaminate this article.

When benzioc acid contains resin, it often exhales an odour of prussic acid when boiled with nitric acid, and the benzoic acid which crystallizes in cooling, instead of a feebly acid, has a bitter taste.

BICARBONATE of POTASSIUM. *See* POTASSIUM.

BICARBONATE of SODIUM. *See* SODIUM.

BICHLORIDE of MERCURY (Corrosive Sublimate). *See* MERCURY.

BINOXALATE of POTASSIUM (Salt of Sorrel). *See* POTASSIUM.

BISMUTH.—The bismuth of commerce is generally imported from Saxony; but it is smelted also in Bohemia, Carynthia, Sweden, and Norway. England possesses also a few mines of that metal.

Bismuth being very fusible and generally found native, its separation from the *gangue* or matrix is exceedingly simple and easy. The ore is simply broken to pieces, put into a crucible, and exposed to a red heat. After a while the metal is found agglomorated at the bottom of the crucible, or else the ore is charged in cylinders of cast iron, slightly inclined, and heated therein. The bismuth soon runs from its gangue and flows into pans which are placed at the lower end of the cylinder. Whichever way bismuth is obtained, that of commerce is never pure; it is contaminated by *sulphur*, *arsenic*, *lead*, *silver*, *iron*, *tin*, &c. The analysis of the metal may be performed as follows:—

Put into a crucible a given weight of the bismuth to be examined, and fuse it therein with one-tenth part of its weight of nitrate of potassium, in order to convert the *sulphur* and the *arsenic* into sulphate and arseniate of potassium, which may then be eliminated by washing with water; these compounds being soluble in this menstruum.

The bismuth which is now left, and which may contain *lead*, *silver*, *tin*, &c., is boiled in nitric acid, which oxydizes the tin and leaves it in an insoluble state; it may then be collected on a filter, washed, ignited, and weighed.

The filtrate should next be treated by a slight excess of solution of carbonate of potassium; a solution of cyanide of potassium is then added, and the whole is digested at a gentle heat for some time. The lead and the bismuth which have been precipitated by the carbonate of potassium are left in an insoluble state, but the silver is taken up and remains in solution in the state of double cyanide of silver and of potassium. The whole is thrown on a filter; the carbonate of lead and of bismuth on the filter may then be dissolved in acetic acid, and a blade of pure lead, previously weighed with great accuracy, should be completely immersed in the acetic acid solution. The flask, containing the solution and the blade of lead immersed therein, is to be corked up, and the whole is left at rest for several hours. The bismuth is gradually thrown down in the metallic state by the lead, and when the whole of the bismuth has separated, the blade of lead is removed, washed, dried, and weighed. The bismuth is then collected on a filter, washed with pure water (previously boiled and cooled out of the contact of the air); it is then re-dissolved in nitric acid, and an excess of a solution of carbonate of ammonium is then poured in; the whole is heated for a short time, by which means the oxide of bismuth is completely separated: it is then washed, dried, ignited in a porcelain crucible, and weighed. The filter should be burnt separately on the cover of the crucible, and the ashes are returned to the mass to be weighed.

The solution of lead which was filtered from the precipitated bismuth is neutralized with ammonia and treated by oxalate of ammonium in order to precipitate the lead in the state of oxalate of lead, which is then collected on a filter, washed, and ignited in a small, open, and counterpoised porcelain crucible, by which treatment it is converted into protoxide of lead, from which the weight of the lead in the compound may be calculated. The loss of weight sustained by the blade of lead employed indicates how much oxide of lead should be subtracted from the total weight of the protoxide of lead obtained. 112 parts in weight of protoxide of lead = 104 of metallic lead.

The filtrate separated from the precipitate at first produced by carbonate of potassium, and which contains the silver in the state of double cyanide of silver and potassium, should be mixed with an excess of dilute nitric acid, and gently heated. The silver is thereby precipitated in the state of cyanide of silver, which is collected on a filter, washed, dried at a steam heat, and weighed. 100 grains of cyanide of silver = 80·6 silver. The silver may also be separated by *cupellation*. (*See* Silver.)

BITARTRATE OF POTASSIUM. *See* Potassium.

BLACK BAND. *See* Iron Ores.

BLACK JACK. *See* Zinc Ores.

BLANC MANGE. *See* Bonbons, Sweatmeats, Liqueurs, Lozenges, &c.

The following substances should never, *under any pretence, nor in any quantity*, be used for colouring jellies, sweatmeats, &c., or any article of food whatsoever:—

Green—	Emerald green	Arsenite of copper.
	Scheele's green	
	Schweinfurt's green	Acetate and arsenite of copper.
	Green verditer	Hydrated basic carbonate of copper.
	Verdigris	Acetate of copper.
	Rinman's green	Cobaltate of zinc.
Yellow—	Gamboge.	
	Chrome yellow	Chromate of lead.
	Orpiment	Sulphide of arsenic.
	Patent yellow	Iodide of lead.
	Turner's yellow	
	Cassel's yellow	
Red—	Red lead	Oxide of lead.
	Minium	
	Cinnabar	Sulphide of mercury.
	Vermilion	
Blue—	Blue verditer	Carbonate of copper and calcium.

In fact, all mineral pigments, except Prussian blue, are more or less dangerous, and therefore should not be employed for colouring edible substances.

The colouring substances which may be employed with perfect safety by confectioners, liqueur-makers, and others, for the purposes mentioned, are the following :—

BLUE COLOURS :—
- Pulverised indigo.
- Sulphate of indigo.
- Prussian blue.

These substances are readily miscible with all the other colours in which blue forms a constituent part; as, for example, with yellow to make green, and with red to make purple.

YELLOW COLOURS :—
- Saffron.
- Turkey yellow berries.
- Persian yellow berries.
- Quercitron.
- Fustic.
- Aluminous lakes of the above woods.

The yellow colour obtained from some of the above substances, and especially from Turkey yellow berries and Persian berries, is more brilliant than that imparted by chrome yellow, which is a poison.

RED COLOURS :—
- Cochineal.
- Carmine.
- Carmine lake.
- Brazil-wood lake.
- Madder lake.

COMPOUND COLOURS.—GREEN COLOURS.—A green colour may be produced by mixing one of the blue colours with one of the yellow colours above-mentioned, but the brightest green is that produced by Prussian blue and Persian berries; the colour thus produced is as beautiful as Schweinfurt green, which is a poison.

PURPLE COLOURS.—A purple colour may be produced by mixing one of the blue colours with one of the red colours above mentioned; any variety of tint may be thus obtained.

A decoction of logwood produces a good violet or purple colour.

A purple dahlia colour may be obtained by mixing carmine lake with Prussian blue.

As to the coloured papers which are sometimes used as wrappers, the most dangerous are those of a fine green or of a light blue colour, produced by means of metallic pigments, and which, when in contact with soft, moist, or greasy substances, such as lard, butter, cheese, sweetmeats, caramel, sugar-plums, &c., may impart to them a portion of their colouring matter, and thus be the cause of serious or even fatal accidents.

Dr. Rasedon, of Mersburg, has directed the attention of medical men to the danger of using Scheele's green, either in painting walls or in staining paper-hangings. He thinks that by the agency of moisture a certain amount of arsenuretted hydrogen is evolved, which materially interferes with the purity of the air. According to Dr. Rasedon, pseudo-rheumatic pains, neuralgia, cough, lassitude, and emaciation, are produced by that state of the air, and these affections get worse with an increase of moisture either in the room or atmosphere.

The glazed paper and cards known as enamel paper, and cards such as are used now generally as cards of visit, are prepared with carbonate of lead (white lead), which is a poison.

Detection of Mineral Colouring Matter in Sweetmeats, Sugar-plums, and other Edible Substances.

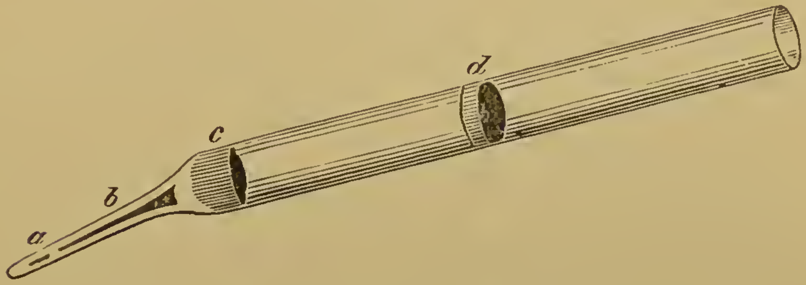
All the mineral preparations above mentioned, being insoluble in water, may be isolated by digesting the suspected articles in water, which dissolves the sugar. The whole being left at rest, the insoluble matter settles at the bottom, and may be separated by decantation, filtering, washing, and drying at a gentle heat.

Scheele's green, or emerald green, or arsenite of copper, *Schweinfurt green,* which is a mixture of acetate and arsenite of copper, are easily recognized as arsenical compounds by the garlic odour which they evolve when thrown upon ignited charcoal, or when mixed with carbonate of sodium and heated before the blow-pipe upon charcoal.

The presence of arsenic may also be rendered evident in the following manner :—Take a glass tube, free from lead, and draw it to a point about one inch long, so that the internal diameter of that part be about the size of a strong knitting-kneedle, as here represented. (Fig. 12.)

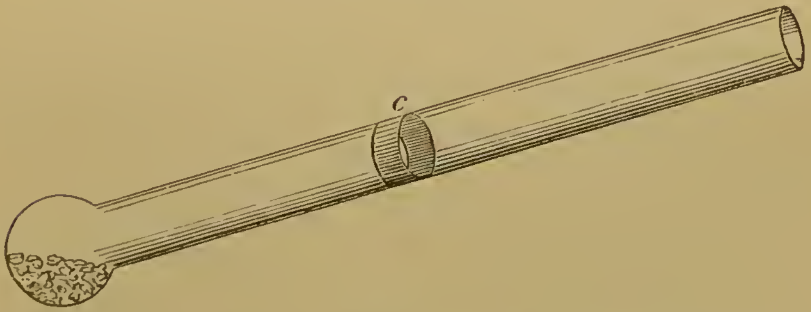
A small portion of the insoluble matter previously dried, and which needs not be more considerable than 0·1 or even 0·01 of a grain, is then carefully introduced at the bottom or closed end of the tube, and a splinter of charcoal *b*, is then dropped upon it. The best charcoal for the purpose is that which is sold in long, thin, porous sticks, and is used by artists for sketching. This done, the operator thrusts into the flame of the spirit-lamp that portion *b* of the tube where the charcoal lies, and when it becomes red-hot, he immediately heats the pointed parts which contains the arsenical compound. The arsenious acid, in passing over the ignited piece of charcoal, is reduced, and a ring of metallic arsenic is first formed at *c*, which may be shifted to *d*, and then back again to *c*, by exposing these parts successively to the heat of the flame of the spirit-lamp. The ring of metallic arsenic having been shifted back into *c*, the tube may be cut off at that point by a file, and on applying heat, the odour of garlic, which is characteristic, becomes immediately perceptible, and thus indicates the presence of arsenic beyond possibility of doubt.

Fig. 12.



Paper which has been coloured with Scheele's green may also be rolled up into a ball and introduced in the bulbous end of the tube represented in Fig. 13, and treated in the same manner; the charcoal of the paper is sufficient to reduce the arsenic, and a metallic mirror is then obtained. It is difficult, however, to detect the presence of arsenic by treating the suspected paper in this manner, because an empyreumatic oil passes over with the fumes, and, condensing on the sides of the glass, masks the metallic mirror. It is therefore better to treat the paper by moderately diluted hydrochloric acid, which dissolves the pigment, and the solution may then be tested for arsenic by Marsh's apparatus.

Fig. 13.



Or the dry residuum above mentioned may be mixed with a little black flux, and heated in a tube closed at one end. (Fig. 12.) If arsenic is present, a metallic mirror of the metal will be formed at *c*.

If the powder which remains in an insoluble state, after digestion in water, contains any *oxide of copper*, the addition of aqueous ammonia will produce a solution of a beautiful blue colour.

Paper which has been coloured with oxide of copper is decolourized when touched with a solution of ammonia; or if the paper be put into a glass, and aqueous ammonia poured upon it, a solution of a beautiful blue colour is obtained. Moreover, paper which has been coloured with a salt of copper burns with a green flame.

Or the dry residuum, or the paper, may be treated by dilute sulphuric acid and filtered. If a portion of the filtrate, being tested with ammonia, produce a blue colour, or with solution of ferocyanide of potassium a reddish brown precipitate, it is a sign that copper is present. A bar of iron, perfectly bright and clean, such as for example the blade of a knife, is also an excellent test for copper; the blade being plunged in the solution will, after a short time, become coated with metallic copper, if that metal be present.

If the colouring matter be *Rinman's green* (cobaltate of zinc), it may be ascertained by dissolving the dry residuum, insoluble in water, in an excess of acetic acid, and passing a stream of sulphuretted hydrogen through the solution, which will produce a white precipitate of sulphide of zinc, whilst the cobalt will remain in solution. The white precipitate may be identified as sulphide of zinc, by redissolving it in muriatic acid, and leaving it to digest until all odour of sulphuretted hydrogen has vanished, filtering, adding an *excess* of ammonia, which will redissolve the white precipitate at first produced by it, filtering again, if necessary, and adding hydrosulphuret of ammonia to the strongly ammoniacal solution, which will reprecipitate the zinc in the state of white sulphide of zinc, which is insoluble in any excess of that re-agent. In fact, when a white precipitate is produced by hydrosulphuret of ammonia in a clear and colourless, strongly ammoniacal, or alkaline solution, it is always owing to the presence of zinc.

The liquor which was filtered from the white precipitate of sulphide of zinc, produced in the first instance by the stream of sulphuretted hydrogen, and which contains the acetate of cobalt, has a pink colour, and yields by evaporation a deliquescent residuum of a purple or blue colour.

Yellow Colours.—If chromate of lead has been used to impart a yellow colour to the suspected article, it may be easily detected in the dry residuum mentioned before, as follows:—

A portion of the dry residuum should be mixed with fused borax, and if chrome be present, a bead of an emerald green colour will be obtained by fusion before the blow-pipe. If, on the other hand, another portion of the residuum be mixed with soda, and heated upon charcoal in the reducing flame of the blow-pipe, globules of lead will be obtained.

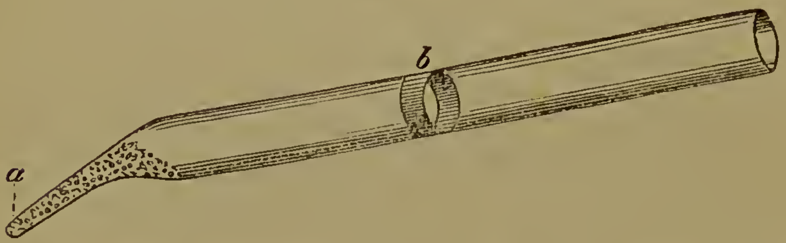
Chromate of lead may also be detected by boiling a portion of the dry residuum in solution of carbonate of potassium, by which it becomes converted into chromate of potassium of a light or lemon yellow colour. The addition of a few drops of nitric acid converts it into bichromate of potassium, and the solution assumes an orange yellow colour. To a portion of this solution add a few drops of acetate or of nitrate of lead; this will produce a yellow precipitate of chromate of lead, soluble in caustic potash. If, instead of nitrate or of acetate of lead, solution of nitrate of silver be employed, a carmine red precipitate of chromate of silver will appear; if the solution does not contain an excess of acid, the precipitate is purple.

All the oxides and salts of lead may be easily recognized by means of the blow-pipe upon charcoal; because, when thus heated in the reducing flame, globules of metallic lead are immediately obtained. The reduction of lead is so easily effected, that ignition is of itself sufficient to accomplish it; for if paper or cards, glazed or enamelled with carbonate of lead, are set fire to, the operator may observe, first, that near the inflamed point a yellow coating is produced, which is oxide of lead, and by looking carefully at the carbonized or charred portion of the paper, a great number of minute globules of metallic lead may be seen.

Carbonate of lead being a poison, it is of course dangerous to use paper enamelled or glazed with that substance, as wrappers for articles of food. There are examples of children having been poisoned by chewing or sucking such cards.

The presence of *orpiment* is recognized in the dry residuum by heating a portion of it to redness on a strip of platinum foil, in which case it will burn with a pale blue flame, and evaporate completely. Thebe st test, however, of the presence of orpiment, is its conversion into metallic arsenic, which is done as follows:—The sulphide of arsenic (*orpiment*), or the dry residuum supposed to contain it, is placed at the end *a* of the tube shown in Fig. 14, and above it a suitable quantity of recently charred tartrate of calcium is added. The portion of the tube containing the charred tartrate of calcium must be heated to redness by means of an argand spirit lamp, and when red-hot, the end *a* of the tube containing the orpiment is brought into the flame of the lamp. The fumes of the sulphuret of arsenic, traversing then the red-hot mixture of lime and charcoal, are decomposed, the sulphur combines with the lime, forming sulphide of calcium, oxide of carbon is disengaged, and a ring of metallic arsenic is deposited at *b*. Care must be taken that the charred tartrate of calcium be hot enough, for the sulphide of arsenic might otherwise be sublimed without decomposition. Instead of tartrate of calcium, oxalate of calcium, mixed with a little carbonate of ammonium, may be used.

FIG. 14.



Gamboge is recognized, because the solution of the sweetmeats under examination retains a yellow tinge, gamboge being partially soluble in water. The best method of identifying this substance consists in digesting the sweetmeats in rectified alcohol, and adding water to the filtered alcoholic solution, by which the resin of that gum will be precipitated. If it be now moistened with ammonia, it will assume a red colour.

Chloride of lead, red lead, and other preparations of lead, may be detected exactly in the same manner as *chrome yellow,* by the blow-pipe, by which means a bead of metallic lead may be obtained; or the residuum may be treated by nitric acid and filtered. The filtrate being then tested with solution of sulphate of sodium, will produce a white precipitate of sulphate of lead; if, instead of sulphate of sodium, it be tested with iodide of potassium, a yellow precipitate of iodide of lead will fall down. Or, if a stream of sulphuretted hydrogen be passed through the filtrate, a black precipitate of sulphide of lead will be produced.

Cinnabar, or *vermilion,* may be detected by dissolving the residuum in aqua regia, diluting with water, filtering and testing with chloride of barium, which will then produce a white precipitate of sulphate of barium, the sulphur of the sulphide of mercury (vermilion) having been converted into sulphuric acid by the action of the aqua regia. Remember, however, that sulphides always yield a portion of sulphuric acid when treated by aqua regia or nitric acid, and therefore this test is not conclusive, except the absence of other sulphides has been previously ascertained. Another way consists in mixing a portion of the red sediment with soda slightly moistened, and introducing the whole into a glass tube closed at one end. If the extremity of the tube be now exposed to a red heat, the mercury will be revived, and will sublime in the form of a grey coating, in which the presence of globules of mercury may be rendered apparent, if not already so, by rubbing with a glass rod. The vermilion may also be identified as such by heating it without soda in the glass tube, when the vermilion will sublime without alteration in the form of a red powder.

Toys are generally coloured or painted with poisonous substances of the same description as those above mentioned, and fatal accidents have happened from children having applied them to their mouths.

BLEACHING POWDER. *See* Lime, Chloride of.

BLENDE. *See* Zinc Ores.

BLUE CARBONATE OF COPPER. *See* Copper.

BLUE COPPERAS. *See* Copper.

BLUE VITRIOL. *See* Copper.

BONBONS. *See* Blanc Mange.

BORACIC ACID.—Boracic acid is found in an uncombined state in several small muddy lakes of Tuscany and of Sesso called *lagoni*, in the midst of which small craters called *suffioni* are opening, and which disengage aqueous vapours charged with boracic acid, borate and sulphate of ammonium, of iron, and other salts, as is shown in the analysis of the boracic acid of Tuscany, by Payen, which we reproduce here:—

Pure crystallized boracic acid	74·0	to	84·0
Sulphate of magnesium	14·0	„	8·0
„ of ammonium			
„ of calcium			
Chloride of iron			
Alum			
Clay, sand, sulphur	2·5	„	1·25
Hygroscopic water disengaged at 35° centigrade	7·0	„	5·75
Nitrogenized organic matter	2·5	„	1·00
Sal ammoniac			
Hydrochloric acid			
Sulphuretted hydrogen			
	100·0		100·0

According to the above analyses the boracic acid of Tuscany contains, therefore, from 16 to 26 per cent. of foreign matter.

The best way of estimating the value of boracic acid consists in combining it with a base—for example, with soda—and decomposing the borate thus formed by adding sulphuric acid, exactly as for the analysis of borax, as described under that head.

BORATE OF SODIUM. *See* Borax.

BORAX (**Borate of Sodium, Tincal, Pounxa, Crysocolla**).—Borax is a combination of boracic acid with sodium, which is found in, and is exported chiefly from, India, in an impure state, and is naturally covered with a kind of fatty or soapy matter. In that impure state it is in hexaëdral crystals, more or less flattened, of a yellowish or green colour, and it is then known under the name of *tincal*, or of *crysocolla;* it is only after purification that it is called *borax*; it is then white, and in slightly efflorescent, irregular hexaëdral prisms, slightly styptic, and has an alkaline re-action on test-papers. Borax, however, is manufactured also by combining directly soda with native boracic acid. (See *Boracic Acid.*)

The assay of borax may be made very easily by a process contrived by Gay-Lussac, and similar to that employed in alkalimetry. Since sulphuric acid decomposes borate of sodium in a complete manner, if we employ sulphuric acid of a known strength, the quantity which will have been required to decompose a known weight of borax will indicate the quantity of soda contained in the salt, and therefore the proportion of borax which corresponds to that quantity of soda may be readily calculated.

The *modus operandi* is as follows:—

Dissolve 100 grains of the borax under examination in about 1,000 grains-measure of pure water, with the help of heat, and add thereto a few drops of tincture of litmus, so as to impart a blue tinge to the solution. This done, pour into an alkalimeter 1,000 grains-measure of test-sulphuric acid of specific gravity 1·032 (1,000 grains-measure contain 1 equiv. of dry acid, and can therefore neutralize 1 equiv. of each base, see *Alkalimetry*), and add it gradually to the solution of the borax. The solution at first assumes a vinous or purple hue, and at last one or two drops of the test-sulphuric acid in excess change it into the characteristic red colour which indicates that the point of saturation is obtained. In order, however, to detect this change of colour more easily, M. Gay-Lussac recommends to tinge a similar quantity of water with litmus to redden it, with two drops of test-sulphuric acid, and to compare the tint of this liquor with that of the solution of borax under examination. As the boracic acid contained in the hot solution of borax, and which is deposited when the point of saturation is obtained, interferes with the ready appreciation of the changes of colour, the solution should be allowed to cool before adding the last drops of acid. When the tinge produced in the borax liquor is exactly like that of the coloured water kept for comparison, the operator reads off the number of divisions of the test-acid employed, and then calculates therefrom the value of the borax assayed. The indication is a little too high, because it is necessary to pour a little excess of acid to produce a distinct reddening, and therefore it is customary to deduct three drops from the number indicated by the alkalimeter.

The number of divisions represents the quantity of real soda contained in the borax; let us suppose, then, that 50 divisions have been required to decompose the 100 grains of borax analyzed; since 100 divisions represent one equivalent, or 32 of soda, it is evident that, in that case, only one-half equivalent, or 16 of soda, were present in the 100 grains of borax.

Now pure borax consists of—

1 equivalent of soda . . . = 32
1 „ of boracic acid . = 70
10 „ of water . . = 90

1 equivalent of borax = 192

The operator may therefore easily calculate what quantity of borax corresponds to the 16 grains of soda found in the experiment:—

Soda. Borax. Soda. Borax.
$32 : 12 :: 16 : x = 96$

In the case above alluded to, therefore, the sample contains 96 per cent. of crystallized borax.

The adulterations of borax generally consist of *common salt* and of *alum*. These impurities may be easily detected; the first, by solution of nitrate of silver, which will immediately produce a white curdy precipitate of chloride of silver, insoluble in dilute acids, soluble in a slight excess of ammonia, and which may be separated by filtering, or by decantation after it has well settled. The presence of alum is recognized by the white bulky precipitate which ammonia produces when poured in the liquor, which precipitate is soluble in a solution of caustic potash. The adulteration of borax with alum is sometimes so considerable that, on adding ammonia, the whole solution stiffens into a thick jelly. When this is the case, the presence of alum may be readily detected, even by the taste, the alum having a styptic astringent, *slightly acid* flavour, whilst that of borax is sweetish and *slightly alkaline*; and the solution, if it contains alum, reddens the tincture of litmus, whilst that of borax, on the contrary, renders reddened litmus paper blue again. If the borax has been falsified with one-tenth part of its weight of alum, it does not completely dissolve in water; that is to say, the liquor remains turbid, and a slight whitish sediment settles down in the glass.

BRANDY, GIN, RUM, WHISKY.—Brandy, gin, rum, &c. are alcoholic liquors, obtained from the distillation of certain fermented substances. Pure brandy is obtained from the distillation of wine; has a pungent, agreeable taste, barely recognizable, however, in the mixture of alcohol and water coloured with burnt sugar, flavoured with pepper, cayenne, or other acrid substances, to make believe in a strength of alcohol, the proportion of which is attenuated to the least possible amount.

The brandy made from raisins, corn, potatoe, kirschen, barley, and known under the names of gin, rum, whisky, &c., contain a small quantity of a peculiar oil to which they owe their respective flavour. All these liquors, however, are often adulterated to a great extent, the endeavour of the maker being always to reduce the proportion of the alcohol, and to dissimulate its absence by the introduction of pungent or of acrid substances. This fraud may be easily detected by simply evaporating at a gentle heat a known quantity of the liquor to dryness; the acrid matter will then be left behind, and may be recognised by its flavour.

The principal and most esteemed brandies are the brandies of Cognac, Armagnac, Languedoc, Anjou, Bordeaux, Rochelle, Charenton, Orleans, Burgundy, and Champagne.

Brandy, when newly distilled, is white; but that met with in commerce is always of a yellowish, brown, or dark brown colour, which is due to the presence of some extractive matter, and of tannic acid, which it has dissolved from the oak-casks in which it has been kept for a long time. But in order to simulate this colour of genuine brandy, the brandy of commerce is nothing else than new brandy or alcohol, at once converted apparently into old brandy by means of caramel, or burnt sugar.

Genuine French brandy has always an acid re-action upon test-paper, that is to say, it reddens blue litmus paper, because it always contains a small portion of vinegar, and when treated by a persalt of iron, it turns black, owing to the presence of tannic acid; but new brandy, coloured by caramel, is not altered by a solution of persulphate of iron.

The proportion of alcohol contained in brandy may be determined by means of the hydrometer, or of the specific-gravity bottle, in the manner described in the article on *Alcohol*, or by distilling a portion of the sample and taking the specific-gravity of the distilled portion. This must always be done when the brandy, being mixed with sugar or other matters, the operator wishes to ascertain the quantity of alcohol present. The specific gravity of genuine brandy is generally from 0·9695 to 0·9237.

In 1824 M. GAY-LUSSAC invented an instrument called alcoholometer (alcomètre centésimal), on the principle of the hydrometer. The instrument, when immersed at 15° centigrade (59° Fahrenheit) in a mixture of alcohol and water, indicates at once the quantity, in bulk, of alcohol present in the liquor. The alcoholometer is divided into 100 degrees, and is so contrived that each degree represents one hundredth part of anhydrous or pure alcohol. Suppose, for example, that at the temperature of 15° centigrade (59° Fah.), the alcoholometer, being plunged in a sample of brandy at that temperature, sinks to the point marked 50°, it indicates that the brandy under examination consists of equal volumes of pure alcohol and of water. By means of such an instrument, therefore, the real quantity of alcohol contained in a given quantity of spirit can immediately be determined by multiplying the volume by the number of degrees indicated by the immersion of the instrument, and dividing the product by 100. Thus, if a sample from a puncheon of brandy containing, for example, 135 gallons, being brought to 15° centigrade, indicates 50° of the alcoholometer, the 135 gallons will therefore contain 67½ gallons of pure alcohol—

$$135 \times 50 = 6750 \div 100 = 67{\cdot}50,$$

or, which is the same thing—

$$135 \times 0{\cdot}50 = 67{\cdot}50.$$

Had the alcoholometer indicated 45°, then the 135 gallons in the above example would have contained 60¾ gallons of pure alcohol.

$$135 \times 0{\cdot}45 = 60{\cdot}75 \text{ (\textit{see} ALCOHOL).}$$

Brandy contains sometimes a small quantity of *lead*, from the solder employed in the construction of stills; and of *copper*, from the still itself. *Acetate of lead* (sugar of lead) is occasionally, though rarely, added to brandy, for the purpose of facilitating the clarifying process. The brandy so treated may prove exceedingly injurious or even deadly, acetate of lead being a poison.

The presence of *copper* may be detected by filtering a portion of the brandy through animal charcoal, in order to decolorize it; ammonia is then to be poured into the clear liquor, to which it will impart a blue tinge, if copper be present, at least, in sufficient quantity. Several hours are sometimes requisite to determine the appearance of this colour. The presence of copper may also be detected by immersing at once a blade of perfectly clean iron in the brandy, and leaving it in for a few hours, when it will be found coated with a film of metallic copper. The brandy first decolorized by animal charcoal may also be tested for copper by a solution of ferrocyanuret of potassium (yellow prussiate of potash), which will then produce a brown precipitate, if copper be present.

The presence of *lead* is detected in brandy by means of dilute sulphuric acid, or of a solution of sulphate of sodium, which will produce a white precipitate of sulphate of lead; or better still, by passing a current of sulphuretted hydrogen, which will then produce a black precipitate of sulphide of lead. The white precipitate produced by dilute sulphuric acid, or by solution of sulphate of sodium, becomes black when moistened by hydrosulphuret of ammonia. If the quantity of the precipitate is large enough, it may be mixed with a little soda, and reduced before the blow-pipe upon charcoal. A bead of metallic lead may be thus obtained. (See the article on *Alcohol.*)

An instrument called *ebullioscope*, or *ebullition alcoholometer*, has been invented, by which the quantity of alcohol contained in brandy, wines, beer, and other spirituous liquors, can be easily ascertained in the course of a few minutes. The instrument is based upon the fact that the boiling point of a spirituous liquid is scarcely altered by the presence, in moderate quantities, of the substances which may have been dissolved in it; and which, increasing the density of the liquid, render ordinary alcoholometers or hydrometers useless for the purpose of indicating its alcoholic richness. The ebullioscope, as first invented by M. Brossard-Vidal, modified by M. Conaty and by M. Lerebours, has been greatly improved by Dr. Ure, who published the following observations:—

'That the boiling temperature of water is increased by holding neutro-saline and saccharine substances in solution has been long known, and has been the subject of many experiments, made partly with the view of ascertaining from that temperature the proportion of the salt or sugar, and partly with the view of obtaining a practical liquid-bath. But it seems to have been reserved for the Abbé Brossard-Vidal, of Toulon, to have discovered that the boiling temperature of alcoholic liquors is, in most cases, proportional to the quantity of alcohol, irrespectively of the quantity of neutro-saline or saccharine matter dissolved in them.

When, however, such a quantity of dry carbonate of potash, or sugar, is added to a spirituous liquor as to abstract or fix in the solid state a portion of the water present, then the boiling temperature of that mixture will be lowered in proportion to the concentration of the alcohol, instead of being raised, as would be the case with water so mixed. But, generally speaking, it may be assumed as a fact that the boiling point of an alcoholic liquor is not altered by a moderate addition of saline, saccharine, or extractive matter. On this principal M. BROSSARD-VIDAL constructed an instrument for determining by that temperature the proportion of alcohol present. His chief object was to furnish the Revenue Boards of France with a means of estimating directly the proportion of alcohol in wines, so as to detect the too common practice of introducing brandy into their cities and towns under the mask of wine, and thereby committing a fraud upon the *octroi.**

'M. BROSSARD-VIDAL's apparatus consists of a spirit-lamp surmounted by a small boiler, into which a large cylindric glass bulb is plunged, having an upright stem of such calibre that the quicksilver contained in them may, by its expansion and ascent when heated, raise before it a little glass float in the stem, which is connected by a thread with a similar glass bead, that hangs in the air. The thread passes round a pulley, which, turning with the motion of the beads, causes the index to move along a graduated circular scale. The numbers on this scale represent percentages of absolute alcohol, so that the number opposite to which the index stops, when the liquor in the cylinder over the lamp boils briskly, denotes the percentage of alcohol in it.

'M. BROSSARD-VIDAL's instrument was placed in my hands several months ago (Oct. 1847) by Mr. FIELD, who had obtained a patent in this country for determining thereby the strength of spirituous liquors. I made a great many experiments on the boiling points of alcohol at various successive degrees of watery dilution, and verified the general utility of the contrivance, but I found the construction of the instrument subject to several defects. The mass of mercury to be heated in the large bulb was so great as to occasion some loss of alcohol in the course of the experiment; the length of the thread was liable to be affected by the moisture of the air; it occasionally failed to move the pulley with sufficient delicacy on account of friction, and when the spirit in the lamp got heated in its case it flared up and burnt the thread, thus rendering the apparatus useless till a fresh thread was experimentally adjusted to the beads.

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* *Octroi* is the name of certain dues which are levied upon certain articles of consumption at their entry in town, and the proceeds of which are applied to the various public wants of such towns.

‘On these accounts I renounced the construction of M. Vidal, and adopted a more simple and direct form of indication.

‘It consists, 1, of a flat spirit-lamp, which we will designate *A*, surrounded by a saucer for containing cold water to keep the lamp cool, should many experiments require to be made in succession; 2, of a boiler, which we will designate *B*, and which fits by its bottom cage (*C*) upon the case of the lamp. A damper-plate is used for modifying the flame of the lamp, or extinguishing it when the experiment is completed. A thermometer, which we will designate *D*, made with a very minute bore, in the manner of the Rev. Mr. Wollaston's instrument for measuring the height of a mountain by the boiling-point of water on its summit, is placed in the boiler. The bottom of the scale in this thermometer is marked *P* for proof on the left side, and 100 (of proof spirit) on the right side. It corresponds to 178·6 Fahr. very nearly, or the boiling-point of alcohol of 0·920, specific gravity. The following Table gives the boiling points corresponding to the indicated densities:—

Temp. Fahr.	Specific Gravity.	
178·6	0·9200	P.
179·75	0·9321	10 U.P.
180·4	0·9420	20 ,,
182·00	3·9516	30 ,,
183·40	0·960	40 ,,
185·6	0·9655	50 ,,
189·0	0·9729	60 ,,
191·80	0·9786	70 ,,
196·4	0·9850	80 ,,
202·0	0·992	90 ,,

‘The above Table is the mean of a great many experiments. When alcohol is stronger than 0·92, or the excise-proof, its boiling-point varies too little with its progressive increase of strength to render that test applicable in practice. In fact, even for proof spirits, or spirits approaching in strength to proof, a more exact indication may be obtained by diluting them with their own bulk of water before ascertaining their strength, and then doubling it.

‘The boiling-point of any alcoholic liquor is apt to rise if the heat be long continued, and thereby to lead into error in using this instrument. This source of fallacy may be in a great measure avoided by adding to the liquor in the little boiler about a tea-spoonful (thirty-five grains) of common culinary salt, which has the curious effect of arresting the mercury in the thermometer at the true boiling-point of the spirit, wine, or beer, to enable a correct reading to be had.

'The thermometer is at first adjusted to an atmospheric pressure of 29·5 inches. When that pressure is higher or lower, both water and alcohol boil at a somewhat higher or lower temperature. In order to correct the error, which would hence arise in the indications of this instrument under different states of the weather, a barometrical equation is attached to the thermometer by means of the subsidiary scale.

Having stated the principles and the construction of the ebullition alcoholometer, I shall now describe the mode of its application.

'1. Light the spirit-lamp *A*.

'2. Charge the boiling vessel *B* with the liquid to be tested (to within an inch of the top), introducing at the same time a paper of the powder; then place the vessel *B* (the damper-plate being withdrawn) on to the lamp *A*.

'3. Fix the thermometer *D* on the stem attached to *B*, with its bulb immersed in the liquid. The process will then be in operation.

'The barometrical scale indicated on the thermometer is opposite the mean boiling-point of water. Prior to commencing operations for the day, charge the boiler *B* with water only, and fix the instrument as directed; when the water boils freely the mercury will become stationary in the stem of the thermometer, opposite to the true barometrical indication at the time. Should the mercury stand at the line 29·5, this will be the height of the barometer, and no correction will be required; but should it stand at any other line, above or below, then the various boiling-points will bear reference to that boiling-point.

'In testing spirituous or fermented liquors of any kind, when the mercury begins to rise out of the bulb of the thermometer into the stem, push the damper-plate half-way in its grove, to moderate the heat of the flame. When the liquor boils freely, the mercury will become stationary in the stem; and opposite to its indication, on the left, the under-proof percentage of spirit may be read off at once, if the barometer stand that day at 29·5 inches; while on the right-hand scale the percentage of proof spirit is shown; being the difference of the former number from 100. The damper-plate is to be immediately pushed home, to extinguish the flame.

'The alcoholometer will by itself only indicate the percentage of alcohol contained in any wine, but by the aid of the hydrometer the proportionate quantity of saccharum in all wines may be readily and easily determined. In testing a sample of wine, first take the specific gravity, and suppose it to be 989, then charge the boiler of the alcoholometer with the wine, as directed, and at the boiling-point it indicates the presence of alcohol at 69·6 per cent.$^{\text{up}}$, whose specific gravity will be found to be 979; deduct that gravity from the gravity of the bulk, or 989, and 10 will remain, which 10 degrees of gravity, upon reference to the wine Table, will be found to represent 25 lbs. of saccharine or extractive matter in every 100 gallons, combined with $30\frac{4}{10}$ gallons of proof spirit.

'Sikes's hydrometer will only show the specific gravity of liquids lighter than water (or 1,000), and for wines in general use, their gravities being lighter than that article, will answer every purpose; but there are wines whose gravities are heavier than water, such as Mountain, Tent, rich Malagas, Lachrymæ Christi, &c., to embrace which additional weights to the hydrometer will be required, as for cordialized spirits, &c. In testing a sample of rich Mountain, its s.g. was found to be 1039, or 39 degrees heavier than water; that wine at the boiling-point indicated the alcohol at 72·5 per cent.$^{\text{up}}$; but 980 s.g. deducted from 1039 leaves 59 degrees of s.g.; against 59 of the wine Tables will be found 147–5, or $147\frac{1}{2}$ lbs. of saccharine or extractive matter combined with $27\frac{1}{2}$ gallons of proof spirit to every 100 gallons.

'Should the barometer for the day show any other indication above or below the standard of 29·5, the thermometer scale will then only show the apparent strength, and reference must be had to the small ivory indicator *E*, it being the counterpart of the barometrical scale of the thermometer. Thus, should the barometer indicate 30, place 30 of the indicator against the boiling-point of the liquid, and opposite the line 29·5 will be found the true strength.

'*Example* 1.—Barometer at 30.—Suppose the mercury to stop at the boiling-point, 72-$^{\text{up}}$, place 30 of the indicator against 72 on the thermometer, and the line of 29·5 will cut 69·6-$^{\text{up}}$, the true strength.

'*Example* 2.—Barometer at 29.—Suppose the mercury to stop at the same point, 72-$^{\text{up}}$, place 29 of the indicator against 72 on the thermometer, and the line of 29·5 will cut 74·3-$^{\text{up}}$, the true strength.

'*For Malted Liquors.*—To all brewers and dealers in fermented liquors this principle, by its application, will supply a great desideratum, as it will not only show the alcohol created in the wort by the attenuation, as well as the original weight of the wort prior to fermentation, but it will indicate the value of malt liquors in relation to their component parts. It will likewise be a ready means of testing the relative value of worts from sugar compared with grain, as well as being a guide to the condition of stock beers and ales.

'To ascertain the strength of malt liquors and their respective values, the instrument has been supplied with a glass saccharometer, testing-glass, and slide-rule. Commence by charging the testing-glass with the liquid, then insert the saccharometer, to ascertain its present gravity of density per barrel, and at whatever number it floats that will indicate the number of pounds per barrel heavier than water.

'*Example* 1.—Suppose the saccharometer to float at the figure 8, that would indicate 8 lbs. per barrel; then submit the liquid to the boiling test, with the salt as before directed, and suppose it should show (the barometrical differences being accounted for) 90-up, that would be equivalent to 10 per cent. of proof alcohol. Refer to the slide-rule, and place *A* on the slide against 10 on the upper line of figures, and facing *B* on the lower line will be 18, thus showing that 18 lbs. per barrel have been decomposed to constitute that percentage of spirit; then, by adding the 18 lbs. to the present 8 lbs. per barrel, the result will be 26 lbs., the original weight of the wort after leaving the copper.

"*Example* 2.—The saccharometer marks 10 lbs. per barrel, and at the boiling-point it indicates 88-up, equivalent to 12 gallons of proof spirit per cent.; place *A* against 12, and opposite *B* will be 21½ lbs. per barrel, when, by adding that to the 10 lbs. present, 31½ lbs. will be the result.

'*To Ascertain the Relative Value.*—Suppose the price of the 26 lbs. beer to be 36*s.* per barrel, and the 31½ lbs. beer to be 40*s.* per barrel, to ascertain which beer will be the cheapest, place 26 on the opposite side of the rule against 36, and opposite 31½ lbs. will be 43*s.* 7*d.*, showing that the latter beer is the cheapest by 3*s.* 7*d.* per barrel.

'By taking an account of the malt liquors by this instrument prior to stocking, it may be ascertained at any time whether any alteration has taken place in their condition, either by an increase of spirit by after fermentation and consequent loss of saccharum, or whether, by an apparent loss of both, acetous fermentation has not been going on towards the ultimate loss of the whole.

'This instrument will likewise truly indicate the quantity of spirit per cent. created in distillers' worts, whether in process of fermentation or ready for the still: the only difference will be in the allowances on the slide-rule.

'N.B.—The saccharometers applicable to the foregoing rules for beers, ales, &c., have been adjusted at the temperature 60 Fahrenheit, and will be found correct for general purposes, but where extreme minuteness is required, the variation of temperature must be taken into account; therefore, for every 10 degrees of temperature above 60, 3–10ths of a pound must be added to the gross amount found by the slide-rule; on the contrary, for every 10 degrees below 60, 3–10ths of a pound must be deducted.

'*For Cordialized Spirits.*—The operation in this instance is somewhat different from that of beers, which have the alcohol created in the original worts; whereas, in cordialized spirits, gins, &c., the alcohol is the original, and the saccharine matter, or sugar, is an addendum.

'If 100 gallons of spirit are required at a given strength, say 50 per cent. under proof, 50 gallons of proof spirit, with the addition of 50 gallons of water, would effect that object, and upon testing it by the alcoholometer, it would be found as correct as by the hydrometer. But in cordializing spirits it is different, for to the 50 gallons of proof spirit 50 gallons of sugar and water would be added, thereby rendering the hydrometer useless, except for taking the specific gravity of the bulk, and according to the quantity of sugar present, so a relative quantity of water must have been displaced; and as the sugar has no reducing properties the alcoholometer will only show the strength of the cordial in relation to the water contained in it, as the principle indicates, irrespectively of saccharine or extractive matter present.

'Suppose, in making 100 gallons of cordial at 50-$^{\text{up}}$, 3 lbs. of sugar are put to the gallon, or 300 lbs. to the 100 gallons, that 300 lbs. displacing 18 $\frac{67}{100}$ gallons of water, only 31 $\frac{33}{100}$ gallons of water instead of 50 having been applied; the sugar, without reducing properties, making up the bulk of 100 gallons, which is meant to represent 50 per cent.$^{\text{up}}$.

'The alcoholometer will only show at the full point of ebullition the alcoholic strength in relation to the water in the 100 gallons of the mixture, or 35 per cent.-$^{\text{up}}$, leaving 15 per cent. to be accounted for on the bulk.

'As the quantity of sugar present must be determined before that percentage can be arrived at, a double object will be effected by so doing; namely, eliciting in all instances the quantity of sugar present, as well as the percentage of spirit to be accounted for.

'*Example* 1.—In taking the s.g. of a cordial, suppose it to be found 1076, then submit the liquid to the boiling-point, and having ascertained the percentage of alcohol, and it proves to be 35-$^{\text{up}}$, the s.g. of alcohol at that strength will be found to be 956; deduct 956 from the s.g. of the bulk, or 1076, and 120 will remain; refer that to its amount on the head line of Table No. II. namely 120, under which will be found 3, representing 3 lbs. of sugar to the gallon; and by running the eye down its column to opposite the alcoholic strength indicated (35-$^{\text{up}}$) will be found 14·9, which represents the percentage of water displaced by the sugar, and which amount of 14·9, added to the 35 per cent. ascertained, makes the total upon the bulk 49·9 per cent.$^{\text{up}}$, with 3 lbs. of sugar to the gallon.

'*For Gins, &c.—Example* 3.—In taking the s. g., suppose it be found 957; then submit to the boiling-point, and it proves to be 14-$^{\text{up}}$, whose s. g. is 937, which deducted from 957, leaves s. g. 20; on the head line of Table No. II., under 20, will be found $\frac{1}{2}$, or $\frac{1}{2}$ lb. of sugar to the gallon; and on running the eye down to the opposite 14-$^{\text{up}}$ will be found 3·0, which added to the 14, makes the total on the bulk 17 per cent.$^{\text{up}}$, with 50 lbs. of sugar to the 100 gallons.

'To chemists for their tinctures, &c., this instrument will be found essentially useful.

'N.B.—Care must be taken that the mercury is entirely in the bulb of the thermometer before it is fixed on the stem for operation, and in all cases (except for water) the salt must be used.

'*Conclusion.*—Wines are peculiarly subject to be mystified by adulterations of various kinds. It will prove of great advantage to the public when the relative quantity of fruit, or saccharum, and alcohol requisite to constitute the normal wine of each species is well ascertained.

'Some beers possess a remarkable narcotic power, by which they cause drowsiness and stupor without corresponding previous exhilaration. Such beverages may justly be suspected of having been sophisticated with *cocculus indicus*, opium, or some analogous drug; and this suspicion may become certainty if they be shown by the alcoholometer to contain only a few per cents. of fermented spirit.'

The table No. I., which shows the specific gravity on the bulk of the mixture, bears reference to the table (No. II. on p. 81) of the alcoholometer following.

Gin.—In MUSPRATT'S 'Chemical Dictionary' the following receipts, 'from the note-book of one of the most extensive and respectable distillery rectifiers in the kingdom,' are quoted to show the 'absurd and uncouth' fashion of the prevalent course of procedure in the manufacture of this spirit:—

No. I.—*Table of Specific Gravities, by Syke's Hydrometer, adapted to Field's Patent Alcoholometer for Cordialized Spirits.*

(Temperature, 60°. Specific Gravity of Water, 1,000°.)

60		80		100		120		140		160		180	
Wt.	S. G.	Wt.	S. G.	Wt.	S. G.	Wt.	S. G.	Wt.	S. G.	Wt.	S. G.	Wt.	S. G.
60	922	80	961	100	1000	120	1041	140	1085	160	1129	180	1175
1	924	1	963	1	1002	1	1044	1	1087	1	1131	1	1178
2	926	2	965	2	1004	2	1046	2	1089	2	1134	2	1180
3	928	3	967	3	1006	3	1048	3	1091	3	1136	3	1182
4	930	4	969	4	1008	4	1050	4	1093	4	1139	4	1185
5	932	5	971	5	1010	5	1052	5	1096	5	1141	5	1187
6	934	6	973	6	1012	6	1054	6	1098	6	1143	6	1189
7	936	7	975	7	1014	7	1056	7	1100	7	1146	7	1191
8	938	8	977	8	1016	8	1058	8	1102	8	1148	8	1194
9	940	9	979	9	1018	9	1061	9	1104	9	1150	9	1196
70	942	90	981	100	1020	130	1063	150	1107	170	1152	190	1199
1	943	1	983	1	1022	1	1065	1	1109	1	1155		
2	945	2	985	2	1024	2	1067	2	1111	2	1157		
3	947	3	987	3	1026	3	1069	3	1113	3	1159		
4	949	4	989	4	1029	4	1071	4	1116	4	1162		
5	951	5	991	5	1031	5	1074	5	1118	5	1164		
6	953	6	993	6	1033	6	1076	6	1120	6	1166		
7	955	7	995	7	1035	7	1078	7	1123	7	1168		
8	957	8	997	8	1037	8	1080	8	1125	8	1171		
9	959	9	999	9	1039	9	1082	9	1127	9	1173		
80	961	100	1000	120	1041	140	1085	160	1129	180	1175		

British Gin.—The still is charged with 300 gallons of liquor and 650 gallons of spirit from a previous rectification, to which are added

95 lbs. German juniper berries,
95 lbs. coriander seeds,
47 lbs. crushed almond cake,
2 lbs. angelica root, and
6 lbs. liquorice powder.

The whole is well *rummaged*; distillation commenced; and after the worm is cleansed by the first portion drawn over into the *faints back*, about 160 gallons are run into *forcing back* No. 4, then turned off into back No. 3 till it runs 1 to 9 or 11 per cent. over proof, when it is turned into faints back No. 8. About 400 gallons are found in back No. 3. Liquor is run into back No. 4, to reduce it to 50 per cent. under proof. It is fined by throwing into it two pounds of *alum* dissolved in boiling water, and leaving it to rest for about eight hours; after which this *low gin* is pumped back into No. 3, containing the remainder of the charge, to bring it to 22 per cent. under proof; then the whole is pumped into store casks for use—the result being 1,100 gallons.

No. II.—*Table showing the lbs. of Sugar per gallon in Cordial Spirits, with the per centages to be added to the indicated Strength, per the Alcoholometer.*

Difference of Gravity. lbs. of Sugar per Gallon.		10 4 oz. or 25 to 100.	15 6 oz. 37½ to 100.	20 8 oz. 50 to 100.	25 10 oz. 62½ to 100.	30 12 oz. 75 to 100.	35 14 oz. 87½ to 100.	40 oz. 1·0	45 oz. 1·2	50 oz. 1·4	Difference of Gravity. lbs. of Sugar per Gallon.	
Sp.Gr. of Spirit.	Pr.Ct. of Spirit.										Pr.Ct. of Spirit.	Sp.Gr. of Spirit.
920	Pf.	1·6	2·5	3·4	4·4	5·3	6·2	7·1	8·1	9·0	Pf.	920
923	2·5	1·6	2·5	3·3	4·3	5·2	6·1	6·9	7·8	8·8	2·5	923
926	5·	1·5	2·4	3·2	4·2	5·0	5·9	6·8	7·7	8·6	5·	926
929	7·5	1·5	2·3	3·2	4·1	4·9	5·8	6·6	7·5	8·4	7·5	929
932	10·	1·4	2·2	3·1	4·0	4·8	5·7	6·5	7·4	8·2	10·	932
935	12·5	1·4	2·2	3·1	3·9	4·7	5·5	6·3	7·2	8·0	12·5	935
938	15·	1·4	2·1	3·0	3·8	4·6	5·4	6·2	7·0	7·8	15·	938
940	17·5	1·3	2·1	2·9	3·7	4·5	5·3	6·0	6·8	7·6	17·5	940
943	20·	1·3	2·0	2·8	3·6	4·4	5·2	5·9	6·7	7·5	20·	943
945	22·5	1·3	2·0	2·7	3·5	4·3	5·0	5·7	6·6	7·3	22·5	945
948	25·	1·2	1·9	2·6	3·4	4·1	4·8	5·5	6·3	7·0	25·	948
950	27·5	1·2	1·9	2·5	3·3	4·0	4·7	5·3	6·1	6·8	27·5	950
952	30·	1·1	1·8	2·4	3·1	3·8	4·5	5·1	5·8	6·5	30·	952
954	32·5	1·1	1·7	2·3	3·0	3·6	4·3	4·8	5·5	6·2	32·5	954
956	35·	1·0	1·6	2·2	2·9	3·5	4·1	4·6	5·3	6·0	35·	956
958	37·5	1·0	1·6	2·1	2·8	3·4	3·9	4·4	5·1	5·8	37·5	958
960	40·	·9	1·5	1·0	2·7	3·2	3·8	4·3	4·9	5·5	40·	960
962	42·5	·9	1·5	2·0	2·6	3·1	3·6	4·1	4·7	5·3	42·5	962
964	45·	·9	1·4	1·9	2·5	3·0	3·5	4·0	4·6	5·1	45·	964
965	47·5	·8	1·4	1·9	2·4	2·9	3·4	3·9	4·4	4·9	47·5	965
967	50·	·8	1·3	1·8	2·3	2·8	3·3	3·8	4·3	4·8	50·	967
969	52·5	·7	1·2	1·7	2·2	2·6	3·1	3·6	4·1	4·5	52·5	969
970	55·	·7	1·2	1·6	2·0	2·4	2·9	3·4	3·8	4·2	55·	970
972	57·5	·6	1·1	1·5	1·9	2·2	2·7	3·1	3·5	3·9	57·5	975
973	60·	·6	1·0	1·4	1·8	2·1	2·5	2·9	3·3	3·6	60·	973
974	62·5	·6	1·0	1·3	1·7	2·0	2·4	2·7	3·1	3·5	62·5	974
976	65·	·5	·9	1·2	1·5	1·8	2·2	2·5	2·8	3·1	65·	976
977	67·5	·5	·8	1·1	1·4	1·7	2·0	2·3	2·6	2·9	67·5	977
979	70·	·4	·7	1·0	1·3	1·5	1·8	2·1	2·4	2·6	70·	979
980	72·5	·4	·7	·9	1·1	1·3	1·6	1·9	2·1	2·3	72·5	980
982	75·	·3	·6	·8	1·0	1·2	1·4	1·6	1·8	2·0	75·	982
983	77·5	·3	·5	·7	·9	1·0	1·2	1·4	1·6	1·8	77·5	983
984	80·	·2	·4	·6	·8	·9	1·0	1·2	1·4	1·6	80·	984
986	82·5	·2	·3	·5	·7	·8	·9	1·0	1·2	1·4	82·5	986
988	85·	·2	·2	·4	·6	·7	·8	·9	1·0	1·2	85·	988
990	87·5	·1	·2	·3	·5	·6	·7	·8	·9	1·0	87·5	990
992	90·	·1	·1	·2	·4	·5	·6	·7	·8	·9	90·	992
994	92·5	—	·1	·2	·3	·4	·5	·6	·7	·8	92·5	994
996	95·	—	—	·1	·2	·3	·4	·5	·6	·7	95·	996
998	97·5	—	—	—	·1	·2	·3	·4	·5	·6	97·5	998

Cordial Gin.—Take 700 gallons of the product of the *second* rectification—(if the improved stills are used, the product of the *first* distillation answers)—and mix it with the following ingredients:—

70 lbs. German juniper berries,
56 lbs. coriander seeds,
5 lbs. almond-cake, crushed and broken,
1½ lb. orris-root, broken,
2½ lbs. angelica-root,
½ lb. cardamum, or instead of this
6 lbs. liquorice-powder are sometimes added.

Force the first running of the working, or about 200 gallons, by reducing it to 50 under proof, adding three-quarters of a pound of alum boiled in two quarts of water. In adopting this receipt, make a double working of it, with twice the quantity of the ingredients. Work in the flavouring in the first charge of rectified spirit, having in the back two or three inches of the usual charge to make up with liquor, and prevent the bottom of the still from injury by the charring of the large amount of ingredients depositing upon it. Turn the distillate into another back, and reduce to 50 per cent. *under proof*; force with a pound and-a-half of *alum*, and pump into fining-cask; then charge with rectified spirit, and work into back containing goods from preceding charge. Run down gin from store-cask, and make up to strength required—17 to 22 under proof.

Plain, or London Gin, is made in the following proportions:—

700 gallons of the second rectification,
70 lbs. juniper-berries,
70 lbs. coriander-seeds,
3½ lbs. almond-cake,
1½ lb. angelica-root,
6 lbs. liquorice-powder.

West Country Gin.—For the manufacture of this spirit the process is—Introduce into the still 700 gallons of the second rectification, and flavour with

14 lbs. German berries,
1½ lb. calamus-root, cut, and
8 lbs. sulphuric acid.

Geneva.—The charge of still being 950 gallons of the second rectification, the proportions are—

84 lbs. juniper-berries,
112 lbs. coriander-seeds,
6 lbs. cassia-buds,

4 lbs. angelica-root,
6 lbs. calamus-root,
6 lbs. almond-cake,
½ lb. cardamum.

Dr. Cameron, Professor of Hygiene in the Royal College of Surgeons, Dublin, has contributed a remarkable article to the 'Dublin Journal of Medical Science' on 'Whisky.'

'During the fermentation of the grain used in the preparation of whisky,' says the Doctor, 'two species of alcohol are formed, namely, ethylic, or vinic alcohol, and amylic alcohol. The former boils at 173° Fahr., the latter at 269° Fahr.; therefore they can be readily separated by careful distillation.

'Amylic alcohol, or fusel-oil, as it is commonly termed, possesses a most acid burning flavour and an oppressive odour. A very minute trace of it in ethylic alcohol greatly injures the flavour and odour of the latter. If the fusel-oil is removed from whisky by rectification, with it are also taken out various others of the acids of the acetic series, and the whisky is converted into common spirit of wine, which few would care to substitute for whisky or brandy, notwithstanding its purity. The fusel-oil and the substances associated with it must therefore be allowed to remain in the whisky until in the course of time they are converted into those compounds of agreeable odour and flavour which characterize old whisky. Those who relish a fiery whisky do not object to that which contains a large amount of fusel-oil; on the contrary, they regard with suspicion and ill favour a glass of Jameson's five-year-old mild whisky.

'New whisky is much cheaper than old, and the bad flavour (to refined palates at least) of the former is often attempted to be disguised by the addition of flavouring materials. For this purpose the following materials are used:—Sherry wine, tartaric and acetic acids, sugar, pine-apple and other fruit essences, tincture of prunes, acetic ether, oil of wine, spirit of nitrous ether, glycerine, green tea, and various other substances. A mixture of burnt sugar, sherry, acetic ether, and tartaric acid, is very commonly used to "convert new whisky into old." These substances are used in very small quantities; and it is doubtful if they ever produce any bad effects upon the animal economy. They, however, are objectionable, because they are often the means of inducing people to drink whisky largely contaminated with fusel-oil.

'Amylic alcohol is almost deserving of the name of rank poison. A small quantity of it in whisky renders the latter an unwholesome liquor; and the bad effects which we constantly hear attributed to the use of adulterated whisky are undoubtedly due to the use of new whisky largely contaminated with fusel-oil. The sale of such whisky should be prohibited. For this purpose it would only be necessary to prevent the removal of spirits from the bonded warehouses until after at least one year's storage. We have reason to believe that whisky is sold in country districts almost immediately after its manufacture.'

Forty per cent. of the insanity flesh is heir to in these days is asserted by medical men to be attributable to drunkenness. Fusel and essential oil knocks down these dipsomaniacs at night, only to pick them up again in the morning. If people must drink, why not drink robur, the new tea-spirit, which is not only free of fusel and essential oil, but contains the well-known refreshing properties of tea, which is a nervine tonic, and, with the alcohol, forms a tonic stimulant, which it stands to reason must be wholesome?

'It would be well for the general public if experiments were made in hospitals upon confirmed dipsomaniacs, to test the effects of robur on their systems. By this means they might by degrees be weaned of whisky, and eventually led round, by way of tea-spirit, to teetotalism. This would be a consummation devoutly to be wished. It is to be feared, however, that in many cases the vantage ground thus gained would only be held long enough to mark the era of a new departure, and a revelling in fusel- and essential-oil once more.'

Public-house Brandy.—Mr. GRIFFIN ('Chemical Testing of Wines and Spirits') states that he found in a sample which he analysed a quantity of *tannin* so large as to become almost like ink when mixed with a salt of iron. It was evidently not a *distilled* spirit; and he says he was puzzled by it till he read in a German book the following instructions for manufacturing Cognac:—

> 'Take of acetic ether ¾ lb.
> ,, spirit of nitric ether ½ lb.
> ,, French wine 8 quarts,
> ,, oak-bark tincture (made with ¼ lb. of oak bark and ½ quart of spirit). ½ quart,
> ,, purified spirit so much as to bring the whole to 150 quarts of 54 per cent. Tralles.

This mixture, after long cellaring, is very similar to real Cognac in taste and odour.'

Here we have a tincture of oak bark mixed with a couple of ethers, commonly used as physic, passed off as Cognac. Mr. GRIFFIN states that he analysed a bottle of brandy from a large grocer and wine merchant. It contained very common spirit, which tasted very powerfully of fusel-oil, a quantity of this oak-bark liquor, and an abundance of sugar.

BRASS (Dutch Gold, Crysocal, Similor, Prince Rupert's Metal, Pinchbeck, Mannheim Gold).—Brass is one of the most important alloys; it consists chiefly of copper and of zinc, in various proportions, according to the use for which it is intended. Besides copper and zinc, brass contains often a certain proportion of tin and of lead. We give here the result of the analysis of several kinds of this alloy.

	Similor				Hammering	Crysocal	Wire		Fine Casting		For Gilding			For Turning		
Copper	80	84	86	88	70	92	66·5	64·2	91·2	91·7	63·7	82	64·45	61·6	65·8	64·2
Zinc .	20	16	14	12	30	6	33·1	33·1	5·6	5·0	33·6	18	32·44	35·3	31·8	32·8
Tin .	,,	,,	,,	,,	,,	6	,,	,,	1·4	2·8	0·2	3	0·25	0·2	0·2	0·4
Lead .	,,	,,	,,	,,	,,	,,	0·4	0·8	1·8	2·5	2·5	1	2·86	2·9	2·2	2·0
	100	100	100	100	100	104	100·0	91·1	100·0	100·0	100·0	104	100·0	100·0	100·0	109·4

The analysis of brass may be performed as follows:—The alloy is dissolved in nitric acid, and the solution concentrated by evaporation; the tin is left in an insoluble state as peroxide, and may be collected on a filter, washed, dried, ignited, and weighed 100 parts = 78·66 metallic tin. The filtered liquor is still further concentrated and sulphuric acid added, then water, with half its bulk of alcohol. This produces a precipitate of *sulphate of lead*, which is collected on a filter, washed, dried, ignited, and weighed 100 parts of sulphate of lead = 68·2 metallic lead. The filtrate is saturated with sulphuretted hydrogen, whereby the copper is precipitated as sulphide, which is received in a filter and washed as quickly as possible with water impregnated with sulphuretted hydrogen; it is removed as completely as possible from the filter, which is then dried and ignited, and the residue mixed with the bulk of the precipitate. The sulphide of copper is decomposed by digesting it with dilute nitro-hydrochloric acid, and, the sulphur being separated, the solution is evaporated with the addition of sulphuric acid until the nitric acid is entirely expelled; a large quantity of water is then added, and the oxide of copper is precipitated by caustic potassa at a boiling temperature. The ignited precipitate contains 79·87 per cent. of metallic copper. From the filtrate from the sulphide of copper the *zinc* is precipitated by boiling with carbonate of potassium or sodium. The basic carbonate of zinc thus formed is, after washing and drying, strongly ignited, by which it is converted into oxide, which contains 80·27 per cent. of metallic zinc.

BREAD.—The following excellent article on Bread and its Adulterations is taken from 'The Sanitarian,' an American monthly journal, published by A. S. BARNES & CO., New York (July 1873):—

'Experience has everywhere shown that bread made from the cereal grains contains more of the essentials to the support of adult human life than any other article of food. To the cereal grains may be added *buckwheat*, which, although belonging to a different family of plants, is nevertheless in its composition analogous to the cereal grains. The superior advantages of wheaten flour as an article of food consist in the great variety of its component parts; it is virtually a *mixed* diet. When carbonic acid gas is in any way formed in, or forced into, dough made of wheaten flour, so as to divide it into a number of little cavities previous to or during the process of baking, bread is made. This is ordinarily accomplished by one of the two following methods:—

'First. By mixing the flour with hot water and adding yeast, and kneading it into dough; fermentation takes place, carbonic acid is disengaged, but the tenacity of the gluten prevents its escape, and the dough is in consequence distended into a cellular mass; a portion of the starch is converted into dextrine and sugar, which process also yields carbonic acid and generates some alcohol, but this is nearly all expelled by the process of baking.

'Lactic and butyric acids and extractive matters are also formed in small quantities. While these changes are essential to the conversion of flour into bread, it is of importance to prevent their going too far; and herein is one of the arts of the baker. *Ostensibly* to prevent excessive fermentation, *alum* is added to check it, while salt possesses also the quality of incorporating an excess of water, and increasing the weight of the loaf.

'In making bread by this process, the proportions are—20 lbs. of flour, 8 to 12 lbs. of warm water, 4 oz. of yeast, a little mashed potato, and 1½ to 2 oz. of salt. 6½ lbs. of dough should yield 6 lbs. of bread.

'Second. Carbonic acid is also disengaged by mixing carbonate of sodium and cream of tartar with dough, or by the use of baking-powders, which are compounds of the salts of sodium and ammonium and tartaric and citric acids.

'Third. *Aërated Bread.*—This is made by forcing carbonic acid through the dough by means of pressure. This process has the advantage of rendering it impossible for the conversion of starch into dextrine and sugar to go too far, and also has the effect of arresting the excessive generation of lactic acid. From 20 to 25 cubic feet of carbonic acid gas are used for a barrel of flour, and about one-half of the carbonic acid is actually incorporated with the flour.

'A barrel of flour will make from 63 to 73 good 4-lb. loaves of bread. The baker always endeavours to incorporate as much water as he can, to increase the number of loaves.

'Good bread contains about 33 per cent. of water; all over this proportion is excess. The lightness or sponginess of bread is its chief attribute in digestibility. Common salt stiffens the dough, whitens and flavours the loaf.

'The following is the composition of wheaten flower, according to the mean of fourteen analyses by Peligot and others, as given by Dr. Parkes in his "Practical Hygiene":—

' *Wheaten Flour and Bran.*

	In 100 parts	
	Flour	Bran
Water	14·0	10·3
Fatty matters	1·2	2·82
Nitrogenous matters (gluten)	12·8	10·84
Albuminous matters	1·8	1·64
Dextrine and sugar	7·7	5·80
Cellulose	1·7	43·98
Starch	50·7	22·62
Mineral salts	1·6	2·52

'Everything else being equal, the greater the amount of gluten in flour the more valuable it is, because the more nutritious; and this it is which gives the flour of wheat its chief distinction—it contains more gluten than any other. Gluten is easy of digestion and highly nutritious, and flour which contains it in greatest abundance is proportionably valuable. The whiteness of flour is no criterion of its good quality, as the bran or coloured crust of wheat contains a larger proportion of gluten than the more central parts of the grain, and, besides, all of the fatty matter, and most of the salts. Bread, therefore, made of flour from which the bran has not been separated is for healthy persons both more nutritious and more wholesome; but for the sick, and especially for persons affected with bowel complaints, bran bread, or flour from which the bran has not been separated, is sometimes fraught with mischief. Very finely-sorted flour, that is, *purely white*, by the total abstraction of the flouring matter, is frequently one-third less valuable in the quality of bread it will make than other of less whiteness, owing to the presence of a larger proportion of gluten. The proportion of gluten also depends somewhat upon the climate in which the wheat is grown, that of warm climates being the richest; and to this quality is due the superior fitness of flour in the south of Europe for the manufacture of macaroni, vermicelli, and Cagliari paste, which is almost pure gluten. Hence it is of paramount importance, in estimating the value of flour, to ascertain the proportion of gluten it contains.'

Amount of Moisture.—To get at the amount of gluten present, the sample must first be examined for moisture, for this is not only one of the most common frauds in bread, but a frequent *wilful* adulteration of flour. As already shown, the proportion of water naturally present in good flour is about 14 per cent. If flour, before packing, is exposed to a damp atmosphere, it very readily absorbs moisture even to a destructive extent, insomuch that it will heat, ferment, and clod; and such flour will be found to have increased from 12 to 15 per cent in weight. The effect of excessive moisture in flour is to destroy the adhesive property of the gluten, and render it unfit for bread; it also favours the growth of *mould*, which renders bread poisonous. The quantity of moisture in flour can be ascertained by heating it. Take any given quantity, say 100 grains, spread it out on a plate, and carefully dry it over a stove, oven, or hot-air bath for an hour, not allowing the temperature to exceed 212° Fahr. lest the flour should be scorched, which may be inferred by change of colour, and if so, it should be discarded, and the experiment repeated. Weigh directly the flour is cold, and the loss of weight represents the percentage of water.

Amount of Gluten.—Having ascertained that the flour does not contain an excess of moisture, make a weighed quantity of it into a stiff paste, and stir with a glass rod for half an hour; then put it into a fine sieve or gauze strainer, and subject it to a gentle stream of *clear* water until it ceases to impart a milky colour. There will remain on the strainer a pale, dirty-looking grey mass, of a fibrous structure, very adhesive, ductile, and extremely elastic. This is *crude gluten*, a compound, according to HASSALL, of no less than four distinct substances—namely, *gluten*, *vegetable fibrin*, a small quantity of *mucine* or *casein*, and oil, in the following proportions:—

Gluten	20·0
Vegetable fibrin	72·0
Mucine (casein?)	4·0
Starch (accidental), a small quantity.	
Oil	3·7
Crude gluten	99·7

The quantity of *crude* gluten in good flour, when dried, is about 14 per cent.; but in the best southern flour it sometimes amounts to 22 per cent.

Pure gluten is obtained by boiling crude gluten in alcohol, and evaporating the filtered solution to dryness. In its composition it closely resembles muscular fibre. Flour which yields less than 8 per cent. should be condemned.

Adulterations.—The quality of gluten is changed, and its quantity lessened, by the following adulterations of flour:—

1. *Moisture*—already described.

2. *Rye Flour.*—When this is present, the gluten is dark-coloured, shiny, and easily separated.

3. *Barley Flour.*—This gives to gluten a dirty-red colour; it is easily separated into masses, but can be drawn out into filaments which, quickly dried, become contorted.

4. *Oatmeal.*—By this the gluten is changed into a yellowish-black colour, and the appearance of a number of fine white specks on the surface.

5. *Pea Meal.*—The gluten is obtained with unusual facility by a mixture of this substance with flour, but it is of a greenish colour, and has the characteristic odour of peas.

6. *Bean Meal.*—Somewhat like the last in giving off the peculiar odour of beans, but renders the gluten hard to obtain, and much altered in properties; instead of being adhesive it is slippery, not easily spread, and of a light yellowish colour.

7. *Potato Starch and Rice Flour.*—These only dilute the gluten without changing its quality, as they consist principally of starch; this substance is the adulteration to be tested. For this purpose take a small portion of the flour to be examined, and add to it an equal quantity of fine sand; by triturating this mixture in a mortar, the starch granules are broken up; then add water, a little at a time, until a homogeneous paste is formed. Let the mixture stand a short time and filter it. To the filtered liquid add an equal quantity of an aqueous solution of *iodine.* If the flour be pure, the liquid becomes of a rosy tint, inclining to *red,* but the colouring quickly disappears; if starch has been added, the solution is violet coloured, and slowly disappears.

Mineral Adulterations.

8. *Lime.*—After letting the milky fluid, obtained in washing out the gluten, stand long enough to settle, pour off the clear water, carefully turn out the cake at the bottom, and dry it. The top of this (being the bottom, of the sediment) usually contains such adulterations as may have been added to give weight; white

sand is sometimes found. Take a portion of this sediment, burn it to ashes, and to these add nitric acid. If *lime* is present, there will probably be effervescence. Neutralize the acid solutions with ammonia, and add oxalic acid: the occurrence of a precipitate will indicate the presence of lime.

9. *Alum.*—This is one of the most common of all adulterations; it is added to flour to make the bread white, and to facilitate the incorporation of water. To detect it thoroughly, char (not incinerate) 1000 grains of the crum of the bread in a covered platinum crucible. Powder the charred mass in a clean iron mortar, and put the powder into a glass flask with a narrow neck; add two drams of hydrochloric acid, half a dram of nitric acid, and two drams of water. Gently heat to dryness on a sand-bath; when dry, boil for a few minutes with half an ounce of water, containing an excess of pure caustic soda made by the direct oxidation of the metal; about 10 grains will be sufficient. Filter and again boil the charred mass with two drams of water, filtrating through the same filter paper, adding this filtrate to the former one. This should be allowed to stand at night, so that the liquid may filter through completely. Carefully neutralize the filtrate with hydrochloric acid; add now 5 grains of phosphate of sodium, and then ammonia in slight excess, so that the precipitate and weight is as phosphate of aluminium, 100 parts of which represent 384 parts of crystallized alum.

Dr. C. Meynott Tidy, to whom the editor is indebted for the above details, adds, the main points are:—

1st. Only to char the bread; to incinerate it is fatal, the alumina becoming changed to an insoluble form, and some of it dissipated as chloride.

2nd. To keep the solution in as small a bulk as possible.

3rd. To see that the precipitate is *entirely* phosphate.

10. *Magnesia.*—The effect of this earth on flour is similar to alum. This and *soap-stone*, or any other substance containing magnesia, is detected thus:—First treat the ashes from the suspected sample for the detection of lime, then filter the remaining liquid, and add to it double its bulk of *chloride of ammonium* and a little ammonia; then add *phosphate of sodium* and stir well. Allow the precipitate to settle, collect it on a filter and wash with dilute ammonia; dry, ignite, and weigh; the ignited residue is *phosphate of magnesium*, containing 36 per cent. of magnesia.

11. *Sulphate of Copper.*—This is a powerful irritant poison. It is detected by treating the ashes of the flour or bread with nitric acid, evaporating to dryness, boiling the residue with distilled water, and filtering. To the filtered liquid, solution of ammonia

and a few drops of carbonate of ammonium are added; on cooling there will be a copious precipitate. Filter and boil to expel the excess of ammonia, and then add a few drops of nitric acid. Divide the liquid into two portions; to one add ferrocyanide of potassium, and to the other hydrosulphuret of ammonia. If there is the least particle of copper present, the former will give a reddish brown, and the latter a dark brown precipitate.

For the discovery of the various mixtures of flour, meal, starch, &c., to the practised microscopist no other means are so simple or so accurate as the *microscope*; under it the various sizes and shapes of the granules in different substances are displayed with unerring certainty.

BRITANNIA METAL. *See* ANTIMONY.

BRITISH BARILLA. *See* KELP.

BROMINE.—This substance, which is used to some considerable extent for the daguerreotype and other purposes, is a liquid of a deep reddish-brown colour, of a disagreeable, suffocating odour resembling that of chlorine gas. Its specific gravity is 2·966, and, when pure, it boils at 116° Fahr. The bromine of commerce, however, often requires a temperature of 248° Fahr. to boil, which, according to M. POSELGER, is owing to the presence of variable proportions of bromide of carbon, resulting from the simultaneous action of bromine upon the ether and alcohol employed in its preparation.

Bromine may be purified by distilling and collecting only the first portions that pass over.

Pure bromine is only sparingly soluble in water; but it dissolves better in alcohol. Its best solvent, however, is ether.

M. POSELGER, in the 'Poggendorf's Annalen,' says:—

'During the distillation of certain samples of bromine of commerce, I observed that the boiling-point of the liquid stood at 478·4 instead of 251·6° Fahr., and that the liquid acquired a lighter and lighter colour, and became in the end perfectly colourless. I carried the distillation to dryness, and found a residue of charcoal.

'In separating the bromine from the last portion of the distilled liquid by means of solution of potash, an oily aromatic colourless liquid was obtained, which, upon analysis, turned out to be bromide of carbon.

'This admixture of bromide of carbon was found in divers samples of bromine of commerce to the extent of 6 to 8 per cent. of the article. It is most probable that the bromide of carbon owes its origin here to the ether used for the preparation of the bromine.'

Bromide of Potassium.—When this salt is suspected to be mixed with iodide of potassium, place a few grains on a paper previously impregnated with starch paste; moisten it, and admit a small quantity of chlorine gas, whereby the iodine is set free, and the paper coloured blue. A better test is the use of bromine water, added to the salt after it has been placed in benzol; if the latter becomes red-coloured, iodine is present.

Detection of Chloride in Bromide of Potassium.—The bromide is first tested for iodine. For this purpose a small quantity of the salt is dissolved in water in a test-tube, and an equal volume of *disulphide of carbon* added. Upon the addition of a few drops of bromine water the disulphide becomes coloured violet under the influence of iodine if this be present. When this is the case, the whole of the iodine must be removed. About ten grammes of the salt are dissolved in distilled water, and bromine water added until the violet vapours are no longer visible upon boiling; the solution is then evaporated to dryness to remove the excess of bromine, and thus is obtained a bromide of potassium free from iodide, but which may contain chloride.

The remainder of the process depends upon the fact that a given weight of *chloride* of potassium requires, for complete precipitation, a much greater amount of a standard solution of nitrate of silver than the same weight of bromide of potassium; while the bromide, for complete precipitation of one gramme, requires 1·428 grammes of nitrate of silver; one gramme of the chloride requires 2·278 grammes. A standard solution of nitrate of silver is first prepared by dissolving 10 grammes of the pure salt in a litre of water, each 1-10th cubic centimètre corresponding to 1 milligramme of nitrate of silver.

One gramme of the bromide, to be examined freed as above from iodine, is dissolved in 100 c.c. of distilled water; 10 c.c. of this solution, representing 6·1 grm. of bromide of potassium, would require, if pure, 14·2 c.c. of the silver solution; chloride of potassium would require 22·7 c.c.

M. Baudrimont has proposed a method of making the final re-action more delicate, by adding a few drops of solution of chromate of potassium to the bromide under examination. The nitrate of silver added at first combines with the whole of the bromine and chlorine in preference, and the complete precipitation is marked by the production of the red precipitate of chromate of silver. It is obvious that the bromide contains more or less chloride, according as the number of burette divisions (divided into 1-10th c.c.) of the silver salt required exceeds 142. With a salt containing 1-10th of its weight of chloride of potassium, 151 divisions are required; and with a mixture of equal weights of chloride and bromide, 185 divisions.

BRONZE (Bell-metal, Gun-metal).—The above alloys consist chiefly of copper and of tin in various proportions, with sometimes a small quantity of zinc or of lead, or of both zinc and lead. The results of several analyses are as follow:—

Bronze of Cannons	Speculum Metal or Mirrors of Telescopes	Coins or Medals	Gongs or Cymbals	Gun-metal, Statues, and large Castings	Bell-metal
Copper . 100	66	93 — 89	78 — 80	92 — 89	80 — 83
Tin . . 11	33	7 — 11	22 — 20	8 — 11	10 — 17
Zinc . . ,,	,,	,, ,,	,, ,,	,, ,,	6 — ,,
Lead. . ,,	,,	,, ,,	,, ,,	,, ,,	4 — ,,
111	99	100—100	100—100	100—100	100—100

Analysis of Bronze, Bell-, or Gun-metal.—The following process has been employed for some years in H. Sainte-Claire Deville's Laboratory at the École Normale ('Chem. News'):—

Dissolve about five grammes of the alloy in strong nitric acid; boil for about twenty minutes; dilute with two or three times its bulk of water, and boil again for the same time. Separate the insoluble oxide of tin; wash, calcine, and weigh. The nitric acid solution freed from the tin is evaporated to dryness, and the residue calcined at a dull red heat. In this manner a mixture of oxides is obtained in sufficient quantity to suffice for at least two analyses.

About two grammes of the finely pulverized oxides are placed in a small platinum or porcelain boat, and introduced into a small glass tube, closed with a good cork, suitable for weighing. The boat, the tube, and the cork having been previously weighed, the weight of the oxides is obtained, after they have been heated to dull redness in the apparatus, through which a current of dry air circulates. After having weighed the whole, the current of air is replaced by dry hydrogen, and the tube is heated over a lamp until the contents cease to lose weight. It then contains *unreduced* oxide of *zinc*, together with *copper*, *lead*, and iron in the metallic state.

The colour of the product shows the operation when the experiment is concluded. On weighing again, the loss of weight indicates with great accuracy the amount of oxygen contained in these three metals.

If the iron and lead are present in inappreciable quantities, by multiplying this loss by five will be given very nearly the weight of copper present, and in consequence the composition and the alloy itself. In an approximate analysis of gun-metal, the operation will therefore be terminated. If, however, a complete analysis is required, proceed as follows:—

Prepare a roughly standard solution of pure sulphuric acid. Of this solution, in 200 or 300 c.c. of water, take a sufficient quantity to dissolve about double the amount of the mixed iron and zinc which are supposed to be present. Boil the acid liquid to completely expel the air, and cool it in a flask, which should be almost full and well corked; then introduce into it the platinum or porcelain boat, containing the oxide of zinc and the reduced metals. The oxide of zinc quickly dissolves, together with the iron, the solution of which is facilitated by the presence of the metallic copper. The copper and lead remain. The flask must be frequently shaken, so as to diffuse these metals throughout the liquid, and the whole is allowed to stand for some hours; the clear liquid is then carefully decanted, and the metals washed with boiling water.

The solution contains only the sulphates of zinc and iron; evaporate to dryness, heat the sulphates to a temperature of about 400° C., and weigh. If no iron is present, the amount of zinc present may be calculated at once. If iron be present, to the solution of the sulphates acetate of sodium is added in excess, and brisk ebullition will bring down all the iron as basic acetate. From the filtrate acidified with acetic acid a stream of sulphuretted hydrogen will precipitate the zinc.

The mixture of copper and lead is dissolved in sulphuric acid, containing a little nitric acid; the solution, more or less turbid from the presence of sulphate of lead, is heated to about 400° C. The mixed sulphates are weighed, and the sulphate of copper extracted with water. Sulphate of lead will remain; the weight, if subtracted from total weight of the sulphates, will give the sulphate of copper.

BUTTER.—In milk the fatty matter exists in the state of minute globules, suspended in a solution of casein and sugar, and surrounded with a thin white envelope, probably of casein, by which they are prevented from running together, and thereby forming oily drops. When cream (which contains a greater number of oily globules and less water than milk) is heated, the globules rise to the surface, and after a time break through their coverings and run together into a film of melted fat. This union of the globules is also brought about by mechanical means, as in the ordinary practice of churning, and it is greatly promoted by the presence of free acid; hence cream, for the purpose of churning, is usually allowed to become sour. During this process the temperature of the cream rises, and the fatty matter unites into small grains, and finally into lumps, which form ordinary butter. Sometimes the whole milk is churned, and the proportion of butter obtained is said to be thereby increased; the labour, indeed, is much greater in consequence of the difficulty of keeping in motion such large quantities of liquid, but this is compensated for in the neighbourhood of towns, especially in Scotland and Ireland, where there is a ready sale for the butter-milk.

Butter, then, consists of the fat of milk, intimately mixed with a more or less considerable proportion of casein and water, and with a small quantity of sugar and milk; it usually contains, moreover, some colouring matter and some aromatic or other similar ingredients derived from the plants on which the cow has fed, and to which its peculiar flavour is owing.

The proportion of cheesy matter contained in butter varies greatly; it depends, amongst other things, on the mode of preparing the butter, and on the nature of the food on which the cow has been fed. According to CHEVREUL (JOHNSTON'S 'Agricultural Chemistry'), fresh butter, on an average, contains about 16 per cent., five-sixths per cent. of pure fat, and about 16 per cent. of *casein*, *sugar*, and *water*. From these substances the fat of butter may be obtained in a nearly pure state by melting the butter at a temperature of 140° to 180° F., pouring the fluid oil into water of the same temperature, and agitating repeatedly with fresh portions of water as long as anything soluble is taken up. After a time, and in a warm place, the melted fat rises to the surface in the form of a nearly colourless transparent oil, which, on cooling, solidifies into a colourless mass. The fat, thus deprived of its nitrogenous and other impurities, may be preserved, without becoming rancid, for a much longer time than ordinary butter. By submitting pure solid butter-fat to powerful pressure in a linen cloth at the temperature of 60°, a slightly yellow transparent oil will flow out, and a solid white fat will remain behind; the first is called *oleine* or *butter-oil*, and the second *margarine*; and of these two substances the pure fat of butter almost entirely consists, although, as may be supposed, their relative proportions are liable to great variations. The other substances formed in butter are *butyric*, *capric* and *caproic* acids; in perfectly fresh butter they are present in very small quantities only. Thus a sample of butter made in the month of May, analyzed by BROMEIS (JOHNSTON'S 'Agricultural Chemistry,') gave—

	Per cent.
Margarine	68
Butter-oil	30
Butyric, caproic and capric acids . . .	2
	100

but by exposure to the air they are gradually formed in the butter, and it is to their presence that rancid butter derives its disagreeable smell.

Milk on an average yields from 4·5 to 5·5 per cent. of butter, and a cow (says Dr. TIDY) might be stated roughly to yield about one pound daily.

Adulteration of Butter.—In a paper read at a meeting of the Society of Medical Officers of Health, Dr. C. MEYMOTT TIDY relates his experience in his capacity of public analyst as regards butter adulterations. The first adulteration is *water.* 100 grains of pure butter dried in a weighed platinum capsule for several hours at 220° F., loses from 5 to 8 per cent. of water, but by beating out the butter and sprinkling it with water he has been able to incorporate as much as 28 per cent. Out of 130 samples purchased at different shops in Kent, Dr. TIDY found in *seven* 7 to 9 per cent. of water; in *twenty-one* from 9 to 10 per cent.; in *thirty-four* from 10 to 13 per cent.; in *forty-two* from 14 to 17 per cent.; in *seventeen* from 18 to 27 per cent.; and in *nine* over 25 per cent. Thus water might become a very serious adulteration of butter. The next adulteration is *salt.* In the preparation of butter, salt is always added, 4 per cent. being a fair quantity. In *twelve* samples of undoubtedly pure butter, Dr. TIDY found, by the simple process of incineration, 5·2 per cent. of salt; in *twenty-seven* samples purchased indiscriminately he found that two samples contained less than 3 per cent. of salt, *two* between 3 and 4 per cent.; *three* between 4 and 5 per cent.; *four* between 5 and 6 per cent.; *ten* between 6 and 7 per cent; *two* between 7 and 8 per cent; *one* between 8 and 9 per cent.; *two* 10 per cent., and *one* 17 per cent. Over 7 per cent. of salt Dr. TIDY considers excessive. Another adulteration is produced by the incorporation with butter of *dripping, lard, suet,* and other fats. These cannot be mixed with butter when they are in the melted state, but only when cold; hence the mixture is never perfect. The fats, unlike butter, contain *stearine, palmatine,* &c., in considerable amount. To trace the presence of these fats, the melting and solidifying points of the butter must be noted. Butter melts at an average at 75°, and solidifies at 63°; dripping melts at 79·5°, and solidifies at 72·5°, and suet melts at 82° and solidifies at 75°, and suet melts at 82° and solidifies at 75°. Another test is the *taste.* The taste of real butter can be detected even when it has been most extensively mixed. Pure butter melts quickly on the tongue, and there is no sense of granulation; but when adulterated with other fats it melts much more slowly, and a peculiar granulated feel in the mouth is produced as the last few grains disappear. The odours of butter and dripping are easily distinguishable, but the smell of lard when mixed with butter is not so soon detected. Good butter is generally of a rich yellow colour, entirely uniform; but when adulterated the colour is much paler, and it is marbled, owing to the imperfect admixture of other fats. Streaky butter is to be regarded generally with suspicion. In good butter a uniform surface is produced by passing a clean knife rapidly over it, but impure butter has a granulated appearance.

In the Liverpool and Manchester 'Medical and Surgical Reports,' 1873, J. CAMPBELL BROWN, D. Sc. (Lond.) F.C.S., has published a paper on the examination of butter.

In drawing up the following directions Dr. BROWN remarks that he has made free use of the observations of Dr. BALLARD ('Chem. News,' vols. iv. and v.) and the scheme of Dr. PARKES ('Hygeine,' chap. v. sec. xi.), but that he depends chiefly on his own observation on a large number of samples from different sources made in the capacity of public analyst for Liverpool, Cheshire, and the Isle of Man during the years 1871-2.

SCHEME FOR EXAMINATION OF BUTTER.

1. Weigh out an ounce of the sample and place it in a test-tube seven-eighths of an inch in diameter, and melt by placing it in hot water. Place a thermometer with a pear-shaped bulb so that the bulb shall be in the middle of the fat, about 1 inch below the surface, and allow the whole to cool spontaneously. If the quantity of water contained in the butter be large, it will collect in the tube below the fat; the *casein* will also collect in the lower part of the tube. Watch the mass as it cools, and note when solidification commences and when it is complete. The following are the average solidification-points:—

With *pure butter* the thermometer is obscured between 74° and 68°, and the mass is solid at 60°.

Beef dripping obscures the thermometer at 79° and is solid at 72°.

Mutton dripping obscures the thermometer at about 85° and is solid at about 84°.

Lard obscures the thermometer at 84° and is solid between 79° to 70°; but it often remains soft as butter at a much lower temperature.

Mixtures solidify at intermediate temperatures.

2. Determine the quality of the butter by the taste and smell of the re-congealed fat and of the original sample.

3. Examine several portions of the original sample by means of

a good microscope, using a $\frac{1}{4}$ or $\frac{1}{8}$ inch object-glass. In butter made from milk or cream nothing is seen except the characteristic globules and the granular masses of curd and the cubical crystals of salt. The hard fats of butter are present in the globules in a state of solution, and are not recognizable in a separate form.

If *stearic acid* or *palmitin* be present in a separate form, they will be recognised by single fusiform crystals. They indicate the presence of melted fats.

Other substances, such as *starch, flour, palm-oil* corpuscles, *Irish moss*, colouring matter, &c., may also be distinguished by the microscope as distinct from butter or fats.

4. Examine the same portions with the same object-glass, together with a polariscope consisting of two NICOL'S prisms and a selenite plate. The crystals referred to in (3) polarise light, and when viewed by the microscope are more distinctly defined. Particles of *suet* and other fats, which have not been melted, may also be distinguished by their action on polarised light, by their amorphous form, and by their membranes.

5. Repeat the microscope examination after the addition of tincture of iodine, acetic acid and other reagents employed for detection of substances other than fat.

6. Weigh carefully a convenient quantity of the sample, say *one ounce*, in a tared porcelain dish, evaporate in a water-bath until free from water, and weigh again. The difference in the amount of water per ounce should not exceed 35 grains (5 to 10 per cent. according to PARKES).

7. Dissolve the residue in ether, warming gently till the whole of the fat is dissolved; filter through a weighed filter-paper, collecting the filtrate in a beaker; then wash the dish and filter-paper with ether until the whole of 5 or 6 oz. has been used, and allow the whole to stand for some time at the temperature of 65°.

8. Dry the precipitate on the filter and weigh. Deduct the weight of the filter-paper; the remainder is (approximately) the amount of lard, or casein and salt.

9. Wash the precipitate with boiling water and dry at 212° and weigh; deduct the weight of the filter-paper; the remainder is the amount of lard or casein, which in good butter should not exceed 15 per cent. (3 to 5 per cent. according to PARKES).

10. Estimate the salt by means of nitrate of silver in the aqueous washing from (9), or wash a weighed portion of the butter thoroughly with distilled water and determine the salt by nitrate of silver. It should not amount to more than 8 grains per oz. in fresh butter (0·5 to 2 per cent. according to PARKES); or 35 grains per oz. in salt butter (8 per cent. according to PARKES).

11. If the ethereal solution of the fat from (7) has formed a deposit at 65°, decant and filter off the clear solution, and examine the deposit, which is probably *stearin*, according to (12).

Allow the ethereal solution to evaporate down to 3 oz. and let it stand for some time at 65°. Filter off the deposit, which may still contain some *stearin* mixed with *palmitin*, and examine it separately, according to (12). If the butter is adulterated, some of the *stearin* and much of the *palmitin* will still remain in solution, and may be obtained by continuing the process of spontaneous evaporation.

Some samples of *pure* butter yield no deposit from 3 oz. of ether at 65°; but fairly good butter will generally form a slight deposit, the amount of which varies in different samples. A sample of butter known to be pure should be examined side by side with the sample supposed to be adulterated; and as *winter* butter is more solid fat than *summer* butter, the former should be chosen for the comparative experiment.

12 (*a*). Place each of the above-mentioned deposits in a thin weighed glass tube, and, after evaporating off the ether, weigh the fat, and determine its melting-point. Melt carefully, and allow it to cool gradually. Place a small accurately-graduated thermometer with pear-shaped bulb in the melted fat, and observe the temperature at which the latter begins to solidify. When quite solid, rewarm the tube gradually, by placing it in water, the temperature of which is slowly raised, and observe the remelting point of the fat.

(*b*). Or melt the fat in a thin glass or porcelain dish, floated in water, the temperature of which is slowly raised, a thermometer being placed in the water. In this case the apparent melting point will be 2 or 3 above the correct figure; but the relative differences between the melting points of the several deposits will be the same as in (12 *a*).

13. Determine the taste and smell of each of the deposits.

14. The number of grains per oz. may be reduced to parts per cent. by multiplying by the factor 0·22857.

BUTTER OF COCOA. *See* OILS.

CAJEPUT-OIL.—Cajeput-oil is an essential or volatile oil extracted by distillation from the dried leaves of the cajeput-tree (*Melaleuca leucadendron*, *Melaleuca cajeputi*, *Melaleuca leucadendron* of LINNÆUS), which grows at Amboyne, Borneo, and other Eastern islands. It is transparent, of a fine green colour, very fluid, lighter than water, very volatile. It has a strong odour resembling that of a mixture of camphor and oil of turpentine, or rather of camphor and cardamums; it has a pungent and fresh taste, analogous to that of camphor. The green colour is often due to the presence of oxide of copper, from the copper flasks in which it is generally imported, but this colour does not seem to be altogether referable to that substance, for according to LEVERKÖN the green cajeput-oil consists of two oils which may be isolated by distillation; at first $\frac{7}{8}$ths of the oil operated upon pass off in a colourless state, and of a specific gravity 0·897; then a green oil comes over much more slowly, and of a specific gravity 0·920, of a more feeble odour and more acrid taste.

The presence of copper is easily detected in cajeput oil, by pouring some very dilute hydrochloric acid in the oil, shaking the whole well, decanting the oil, and pouring a solution of ferrocyanide of potassium in the residuary liquor, which will then assume a red or reddish-brown colour from the precipitate of ferrocyanide of copper produced.

The presence of copper may also be recognised by immersing a bar of bright iron in the liquor treated as above, when a deposit of metallic copper will take place on the bar of iron.

Cajeput-oil is often adulterated with essential oil of turpentine, of rosemary, or of savine with addition of camphor, &c., and coloured with resin of milfoil (*Achillea millefolium*).

CALAMINE. *See* ZINC ORES.

CALOMEL (Subchloride of Mercury, Chloride of Mercury, Aquila Alba, Mercurius Dulcis). *See* MERCURY.

CAPIVI. *See* COPAIBA.

CAPSICUM. *See* CAYENNE PEPPER.

CARBONATE OF AMMONIUM (Sesquicarbonate of Ammonium); Smelling Salts.

The *sesquicarbonate of ammonium* of commerce often contains *sal ammoniac*, *sulphate of ammonium*, some *organic matter*, and also sometimes traces of *carbonate of lead* or a *salt of calcium*. These impurities may be detected as follows:—

Pure sesquicarbonate of ammonium, being heated in a platinum crucible, should evaporate without residuum. If a carbonaceous residue is left, it is owing to the presence of organic matter; if it is fixed, it may be carbonate of lead, or a salt of calcium, which are distinguished from each other by moistening the residue with hydrosulphuret of ammonia, by which it will be blackened if lead is present; whilst it will undergo no change of colour if it consists of lime. Moreover, if the ammoniacal salt contains carbonate of lead, the latter substance will remain in an insoluble state in treating the salt with water.

If *sal ammoniac*, or any other chloride be present, the sesquicarbonate of ammonium under examination should be dissolved in water, and the solution, being tested by nitrate of silver, will then produce a white turbidness or precipitate, according to the amount of the chloride present.

If sesquicarbonate of ammonium be contaminated by *sulphate of ammonium,* an addition of nitrate of barium to the aqueous solution of the salt, previously supersaturated with nitric acid, will produce a precipitate of sulphate of barium.

As these impurities exist generally in exceedingly small quantities only, their amount is best estimated by means of test-liquors of nitrate of silver, or of barium, of a known strength. The analytical process is then managed exactly as was described in the article on *Alkalimetry.*

When sesquicarbonate of ammonium is contaminated by *empyreumatic oil,* it leaves a small carbonaceous residuum after ignition, and its solution in dilute acids is brown or even black.

As sesquicarbonate of ammonium, when left exposed to the air, becomes gradually converted into bicarbonate of ammonium, a little of the latter salt is always present.

Pure sesquicarbonate of ammonium is translucid and colourless.

CARBONATE OF BARIUM.—Carbonate of barium is often adulterated with *sulphate of barium,* or, at any rate, that which is sold as carbonate of barium contains sometimes an extremely large proportion of sulphate of barium, the presence of which, however, is easily detected by dissolving a portion of the sample in dilute hydrochloric or nitric acid. If sulphate of barium be present, it will remain in an insoluble state, for carbonate of barium is completely soluble in both these acids.

Sulphuric acid being poured in the above solution, should reprecipitate the whole of the barium in the state of sulphate of barium, which being washed, dried, ignited, and weighed, should be in the proportion of 117 grains for every 99 grains of carbonate of barium operated upon; and the liquor filtered from the sulphate of barium so produced should not yield the slighest precipitate by caustic ammonia, nor by hydrosulphuret of ammonia, carbonate of potassium, or of sodium, oxalate of ammonium, or other reagents. Any precipitate which may be so produced is an impurity.

Whether the carbonate of barium under examination is pure or not may also be ascertained by boiling a certain quantity of it in distilled water, filtering, and evaporating the filtrate to dryness. If a residuum is left, it is an impurity. However, FRESENIUS has shown that carbonate of barium is not *altogether* insoluble in water, since 14137 parts of water dissolve one part of carbonate of barium.

CARBONATE OF COPPER. *See* COPPER ORES.

CARBONATE OF LEAD (White Lead, Hamburg White, Dutch White, Venice White).—White lead is a combination of carbonic acid and lead, of a fine white colour, insoluble in water; it is decomposed by a red heat, which expels the carbonic acid and leaves protoxide of lead.

White lead is a most important article of commerce; it forms the base of most oil-paints, and of glaziers' cement.

The genuine white lead of commerce, however, is not altogether pure carbonate of lead; it contains also generally a small portion of hydrated oxide of lead, the presence of which appears to be necessary to obtain the fullest covering or coating power.

White lead is adulterated to an enormous extent; the pigments known under the names of *Hamburg white*, *Venice white*, &c., are in reality acknowledged sophistications of that substance.

The principal adulterations of white lead are *sulphate of barium*, *sulphate of lead*, *chalk*, and *lime*.

The presence of *sulphate of barium* and of *sulphate of lead* may be easily detected by treating a known weight of the white lead (100 grains for example) under examination with an excess of dilute nitric acid. A slight effervescence is at first produced, and when it is seen that, after having boiled the liquor, and although the acid is in excess, all action has ceased, the whole is poured into a large porcelain capsule, and evaporated to dryness at a gentle heat. The dry residuum should then be treated by distilled water, in order to redissolve the nitrates which have been formed, and the whole is thrown on a filter. The precipitate or insoluble portion which is left on the filter, consisting of sulphate of lead or of sulphate of barium, should be carefully washed, dried, ignited, and then weighed.

In order to detect whether this insoluble portion consists of sulphate of barium or of sulphate of lead, a few drops of hydrosulphuret of ammonia should be poured upon it. If it turns black, it indicates that the precipitate consists of sulphate of lead; it remains white, it is sulphate of barium.

As, however, both sulphate of lead and of barium might be present in the white lead under examination, and perhaps also *silica*, in fine powder, it is necessary to proceed as follows:—

A portion of the dry residuum, insoluble in dilute nitric acid, having been well washed and dried, is to be heated before the blowpipe upon a piece of charcoal; and if, upon moistening it with hydrochrolic acid, a distinct odour of sulphuretted hydrogen is evolved, the operator may rest assured that sulphate of barium is present.

Admitting, therefore, that these three substances are present, the operator should thoroughly mix the insoluble and well-washed residuum with about three times its weight of carbonate of potassium, and fuse it for about half an hour in a porcelain crucible, taking care to moderate the heat at first, for fear the mass should boil over. The mass having been fused, and having cooled, is to be treated with hot water, and boiled therewith. The solution is filtered; the filtrate is carefully supersaturated with dilute nitric acid, which should be added by small portions at a time, on account of the effervescence, and the whole is evaporated to dryness. The dry mass being now treated by boiling water, if an insoluble gritty residuum is left, it is *silica.*

If the liquor filtered from the silica, being treated by a current of sulphuretted hydrogen, yields a black precipitate, the white lead contained *sulphate of lead.*

Sulphate of barium may be ignited with the filter without fear of converting it into sulphuret of barium. But as the sulphate of lead would be reduced by the charcoal of the filter, it is better, after drying it, to scrape it off the filter as completely as possible, to burn the filter by itself, and adding the ashes to the sulphate of lead scraped from the filter, to ignite the whole in a porcelain crucible before weighing it.

Several varieties of white lead, known under the names of *Hamburg white*, *Dutch white*, &c., are mixtures of carbonate of lead and of sulphate of barium, generally in the proportions of two or three of sulphate of barium with one of carbonate of lead. Sometimes, also, a pigment is sold as *white lead* which is scarcely anything else than sulphate of lead, which is made in the manufactories of floorcloth by decomposing acetate of lead by alum.

When white lead is adulterated with *lime* or with *chalk,* these impurities may be detected by dissolving a portion of the sample under examination in very dilute nitric acid, and passing a stream of sulphuretted hydrogen through the solution until it smells strongly of that gas; a black precipitate is thereby produced, which is sulphide of lead, which should be separated by filtering. The filtrate should then be boiled until all odour of sulphuretted hydrogen has disappeared; and after filtering again, if necessary, the lime contained in solution in the filtrate may be precipitated by means of oxalate of ammonium in the state of oxalate of calcium, or in that of sulphate of calcium by means of sulphuric acid and alcohol. In the first case the filtrate should be neutralized by ammonia, and on adding oxalate of ammonium a precipitate of oxalate of calcium is immediately produced. When the quantity of the lime has to be determined, the liquor containing the precipitate should be left at rest for a long time, because oxalate of calcium deposits very slowly; it is, moreover, advisable to boil the liquor, and again to allow it to settle well before filtering, else it will pass turbid through the filter. The precipitated oxalate of calcium being collected on a filter, should be washed, dried, and ignited with the filter in a platinum crucible, during which operation oxide of carbon is evolved, which burns with a blue flame; and the residuum, which consists of carbonate of calcium, may then be weighed. If the heat has not been too strong in igniting it, the carbonate of calcium will have lost none of its carbonic acid, and from its weight that of the lime present in the sample is calculated. 50 grains of carbonate of calcium represent 28 of lime.

The determination of the lime, in the state of sulphate of calcium, yields more accurate results. In this case sulphuric acid is first poured in the filtrate, and then alcohol; sulphate of lime, being insoluble in aqueous alcohol, is thus precipitated and collected on a filter, washed with dilute alcohol, dried, ignited, and weighed. 68 grains of sulphate of calcium represent 28 of lime.

The quantity of carbonate of calcium present in the white lead under examination may also be determined by pouring solution of carbonate of ammonium in the liquor from which the black sulphuret of lead has been separated, filtering, and previously boiling it until all odour of sulphuretted hydrogen has disappeared. The addition of solution of carbonate of ammonium will produce a precipitate of carbonate of calcium, which may then be collected on a filter, washed, dried, gently ignited, and weighed. The solution of carbonate of ammonium used for this purpose should first be mixed with a little pure ammonia; and before proceeding to filter the carbonate of calcium precipitated, the whole should be left to digest for a pretty long time in a warm place, so that it may settle well.

CARBONATE OF MAGNESIUM. *See* MAGNESIA.

CARBONATE OF SODIUM (Crystals).—The crystals of carbonate of sodium of commerce are often adulterated to a considerable extent, by mixture with crystals of *sulphate of sodium*, which are only half the price of the carbonate, and which, for detergent purposes, are of no value whatever.

This fraud is very easily detected, and the amount determined, by dissolving a known weight of the crystals in water, supersaturating the solution with nitric acid, and then adding nitrate of barium until a precipitate ceases to be produced. The whole is then boiled, the precipitate (which is sulphate of barium) allowed to settle, and collected on a filter. After washing, drying, and igniting it, it is weighed. 117 of sulphate of barium represent 162 of crystals of sulphate of sodium.

Sometimes, also, the carbonate of sodium of commerce contains *chloride of sodium* (common salt), which is detected by testing the clear solution, acidified with nitric acid (or that filtered from the sulphate of barium first produced), by solution of nitrate of silver, which will produce a precipitate of chloride of silver if chloride of sodium is present. The whole is then boiled a little, and allowed to settle; the precipitate is separated by filtering, washed, carefully dried, and fused in a small porcelain crucible, after which it is weighed. 144 of chloride of silver represent 60 of chloride of sodium (common salt).

It should be borne in mind that the crystals of soda of commerce always contain a *trace* of sulphate of sodium and of chloride of sodium, and also that they contain 62·69 per cent. of water of crystallization.

Bicarbonate of Sodium is very often adulterated with *effloresced neutral carbonate of sodium,* the presence of which is detected by testing the solution, moderately concentrated, with one of perchloride of mercury (corrosive sublimate). If an orange-red precipitate is produced thereby, it is a sign of the presence of a neutral carbonate; if, on the contrary, no neutral carbonate is present, the solution of perchloride of mercury will only produce a slight white precipitate or turbidness. The presence of the neutral carbonate may be detected also by means of solution of sulphate of magnesium, which is not precipitated in the cold by one of bicarbonate of sodium; whilst the neutral carbonate immediately produces a white precipitate of subcarbonate of magnesium.

CARBONATE OF ZINC. *See* ZINC ORES.

CARMINE.—Carmine is a splendid red pigment, obtained from cochineal by a peculiar process. The pigment being very costly, it is often adulterated by an admixture of *starch* of *alumina,* or of *vermilion*; sometimes, also, a portion of the animal matter of the cochineal from which it has been obtained is accidentally left mixed with it. These accidental or intentional impurities are readily detected by heating the carmine with liquid ammonia, which dissolves entirely the colouring matter, and leaves the impurities in an insoluble state. The residuum left should then be dried at a gentle heat (for which purpose a steam-bath answers best), and then weighed.

The difference of colour of the carmine of various shops, *when* *the pigment is genuine*, depends on the quantity of alumina which has been employed to precipitate it; but it depends also upon the carefulness of the manipulation, the purity of the atmosphere, and probably other causes. The preparation of this costly article is not well known, and the secret by which the brighest colour may be obtained is in the possession of only a few persons.

CARTHAMUS. *See* SAFFLOWER.

CAST IRON. *See* IRON.

CAST STEEL. *See* STEEL.

CASTOR (**Castoreum**).—Castor is a substance secreted by the beaver, and found in the inguinal region of the animal in four bags, a large and a small one, on each side.

Whilst the animal is alive, castor is soft, but when the bag which contains it has been removed, it dries up and becomes brittle, but not hard, and of a dull brownish black colour. It can then be easily pulverised.

Castor has a peculiar strong and somewhat disagreeable odour, and a bitter pungent, aromatic, and persisting flavour. The odour of castor is so much stronger as it is fresher, but it loses much of its weight in drying; and therefore in buying castor that which, being dry, has much odour should be preferred. That which is tasteless and inodorous is good for nothing.

Two kinds of castor are met with in commerce; namely, the Russian and the Canadian castor. The best comes from Russia, or rather from Siberia, but that from Canada is now almost the only kind found in shops.

Formerly castor was an exceedingly expensive article, and was in consequence adulterated to a very great extent. Now, however, its price is more moderate; but the adulterating practices, instead of having diminished, seem on the contrary to have augmented in proportion, as if to make up for a reduction in the profit. Not only is castor adulterated, but it is sometimes altogether counterfeited by means of dried blood mixed or kneaded with a gum, such as gum ammonia, with addition, or not, of a little real castor, the whole being put up in artificial bags. This fraud, however, is easily detected by comparing the spurious with the genuine castor, as follows:—

The bags which contain the genuine castor consist of two smaller bags filled with fat, having the odour of castor, or at any rate they present distinct traces of it at the place where they existed.

Genuine castor consists of several superposed membranes, the inner one of which presents, on its external surface, a great number of small silvery scales.

If the contents of the bags are examined the castor will be recognised as genuine, not only because a cavity should then exist in the centre, but also because the castor should be enveloped in membranes to such an extent that it cannot be detached therefrom, either by water or by alcohol, except it be previously dried and broken.

In spurious castor, on the contrary, it will be found that the fat (or indications of its having existed) in the two smaller bags above-mentioned, is wanting, and that the large bag is bigger and rounder than that of the genuine article, and has been imitated with the scrotum of young goats, or the gall vesicle of the sheep; that the contents of the bags consists of a substance either soft or brittle, of a semi-transparent red colour, having only a feeble odour of castoreum; that it easily dissolves in alcohol, and that it turns black when the solution of a persalt of iron is poured upon it, because generally the vegetable substance employed to adulterate it contains tannin.

In spurious castor no trace of the superposed membranes mentioned before are observable.

CASTOREUM. *See* CASTOR.

CASTOR-OIL (Oleum ricini, Oil of Palma Christi).—Castor-oil is obtained from the seeds of the *Ricinus communis*, or *Palma Christi*, either by boiling the seeds first and then subjecting them to pressure, or else by subjecting the seeds to the action of the press, without previous boiling, in which case the oil thus produced is said to be *cold pressed*, and is much superior in quality, being sweeter and less liable to become rancid.

Cold-pressed castor-oil is almost colourless and of a slight, fatty, cloying odour and flavour; it is more viscid than any other oil, and is soluble in all proportions in highly rectified alcohol.

Formerly castor-oil was very often adulterated with fixed oils; this fraud, however, owing to the cheapness of the article, must now be very rare; at any rate it can be readily detected, for all fixed oils, being insoluble in pure alcohol, which, on the contrary, readily dissolves castor-oil, the amount of the impurity may be at once estimated. This is done by pouring a certain quantity of the oil to be examined in a graduated tube, and adding six or eight times its volume of pure highly rectified alcohol. The whole is then to be well shaken and afterwards left at rest. The alcohol, having dissolved the castor-oil, leaves the fixed oil untouched, and its quantity may at once be estimated by the divisions of the graduated tube. It is absolutely necessary that the alcohol employed should be highly rectified; its gravity should not be more than 0·828.

When castor-oil has been obtained by previously boiling the seeds in water, instead of being almost colourless, it has a brownish colour, which, however, is the case with that which has become rancid, no matter how obtained. The rancidity can be removed, it is said, by adding a little caustic magnesia, and boiling for about a quarter of an hour with water.

CATECHU (Terra Japonica, Cutch).—Catechu is an extract prepared in various parts of India and Malabar, by inspissating an aqueous decoction of the fruits and wood of the *Acacai catechu* and *Uncaria Gambir.*

The catechu of *Bombay,* or *Bombay cutch,* is in square masses of two or three ounces weight, of a reddish brown colour, brittle, of a uniform texture, and of a shining and uneven fracture, sp. gr. 1·39. It consists of:—

Tannin	52
Extractive matter . .	34
Mucilage	7
Impurities	7
	100

Bengal catechu, or *cutch,* is in round and flat lumps, weighing from three to four ounces, of a rusty colour outside, and of a dark brown colour internally, more compact than the other varieties. It contains vegetable detritus; its fracture is dull; and its specific gravity is 1·28. It consists of:—

Tannin	49·5
Extractive matter . .	36·5
Mucilage	7·0
Impurities . . .	7·0
	100·0

Malabar cutch is also in amorphous masses, of a rusty colour outside, and internally of a dull, dark brown colour, brittle and gritty, and covered with leaves. Its specific gravity is 1·40. It consists of—

Tannin	45·8
Extractive matter . . .	39·9
Mucilage	8·0
Impurities and sand . .	6·3
	100·0

Catechu is often adulterated by an admixture of various other astringent extracts, or by the incorporation of *sand, clay, ochre,* and other impurities. When, however, other extracts have been mixed with it, the catechu has a dark, almost black colour, and a shining appearance, and it sometimes feels glutinous or clammy. Moreover, the flavour, instead of being astringent, and then sweet and agreeable, is astringent and bitter. As catechu is entirely soluble, both in alcohol and in water, the impurities, the sand, &c., may thus be readily separated.

There is another species of catechu which is manufactured in India, and which comes into this country, in the shape of cubic masses, about one inch in size, externally of the colour of catechu, though somewhat of a lighter hue, but internally of a drab or greenish yellow colour, with a dull, granular fracture. It contains a very large proportion of starch, which may be separated by treating it successively with water and with alcohol. This species of catechu cannot evidently be mistaken for the genuine article, from which it differs in shape, in colour, size, and taste; but samples are occasionally met with which have undergone a certain roasting and steaming process, which have most materially altered that appearance, and rendered it singularly like genuine cutch; the substance, after the above treatment, is almost entirely soluble in water, the starch having been converted into gum by the heat to which it has been submitted. In order to detect this fraud, the proportion of tannin contained in the suspected sample should be determined as follows:—

The catechu under examination must be first reduced to powder, put into a covered vessel, treated therein by boiling water; and the solution thus obtained, being filtered through a piece of linen, sulphuric acid should be poured in the filtrate, until it ceases to produce a precipitate. The precipitate thus formed must now be washed with acidified water, and then dissolved in boiling water. On cooling, a yellowish brown extractive matter falls down, which is to be separated by filtering. The liquor filtered therefrom has a reddish colour, and pulverized carbonate of lead is added thereto, until all the sulphuric acid is thrown down as sulphate of lead; the carbonate of lead must be added so long as a precipitate or turbidness is produced, stirring the whole well. The liquor is then filtered, and the filtrate being evaporated *in vacuo,* the pure tannin is left in the form of a yellow transparent mass, readily soluble in water and in alcohol, which may then be weighed.

A more easy method of ascertaining the amount of tannin contained in the catechu under examination, consists in treating its solution in water by a solution of gelatine; this produces a precipitate, which, being washed and dried at a steam heat until it ceases to lose weight, indicates the quantity of tannin. 100 grains of that dry precipitate contains 40 grains of tannin.

CAYENNE PEPPER (**Capsicum**).—Genuine Cayenne pepper is made by pulverizing the pods of the *capsicum* or *Guinea pepper.* Cayenne pepper contains a white, shining, nacreous, very acrid substance, to which the name of *capsicine* has been given; it is an alkaloid, pretty soluble in water; it contains, besides, a red colouring matter, a little animal matter, mucilage, nitrate of potassium, and other salts. The active principles of Cayenne pepper are soluble in water, in alcohol, and in ether.

Cayenne pepper is often adulterated with *common salt,* finely pulverised *brick-dust,* and, it is said, even with *red lead.*

These frauds may be readily detected by treating a portion of the sample with pure water, filtering, and testing the filtrate with solution of nitrate of silver. If a white curdy precipitate, or only a white turbidness appears, completely and immediately soluble in ammonia, and reprecipitated by an excess of nitric acid, it is chloride of silver, and it indicates that *chloride of sodium* (common salt) is present. The precipitated chloride of silver is washed, dried, fused, and weighed. 144 of chloride of silver represent 60 grains of common salt.

The quantity of *common salt* may also be ascertained by means of a test solution of nitrate of silver, as described in the assay of silver, to which article the reader is referred.

The portion of the Cayenne pepper which remained in a soluble state after treatment with water should now be treated by acetic or by nitric acid, and the whole thrown on a filter. A current of sulphuretted hydrogen must now be passed through the filtrate; and if this produces a black precipitate, it is sulphide of lead, and of course *red lead* was present. Or instead of a current of sulphuretted hydrogen, an excess of dilute sulphuric acid, mixed with alcohol, may be poured in the above filtrate, which will produce a white precipitate of sulphate of lead, which, being collected on a filter and heated until the excess of sulphuric acid is expelled, may then be weighed. 144 of sulphate of lead represent 104 of lead.

The presence of *brick-dust, ochre,* &c., may be ascertained by incinerating the portion which could not be dissolved by the acid; the above inorganic impurities will, of course, be left behind.

Cayenne pepper should be burnt under the hood of a chimney, or in the open air, for the fumes of the oily and acrid resin which it contains are exceedingly irritating, and induce violent coughing.

CEMENTS (Hydraulic). *See* LIME.

CHEESE.—Although all cheese consists essentially of the curd of milk mixed with a certain portion of the fatty matter, and sugar, yet as milk itself is subject to so many natural differences in quality, and as the general mode of dairy management differs so greatly, the varieties of cheese are almost without number, nearly every dairy district producing a quality of its own.

The quality of the cheese will depend, again, on the animal producing the milk. On this subject Professor JOHNSTONE makes the following observations:—

The ewe milk cheeses of Tuscany, Naples, and Languedoc, and those of the goat's milk made on Mount Dor and elsewhere, are celebrated for qualities which are not possessed by cheeses prepared from cow's milk in a similar way. *Buffalo* milk also gives a cheese of peculiar qualities, which is manufactured in some parts of the Neapolitan territory. The strong-tasted cheeses of Lecca, and the celebrated Roquefort cheese, are prepared from mixtures of goat with ewe milk, and the cheese of Mont Cenis from both of these mixed with the milk of the cow. Still further differences are produced according to the proportion of cream which is left in, or added to, the milk. Thus, if cream only be employed, we have the rich *cream cheese*, which must be eaten in a comparatively recent state; or, if the cream of the previous night's milking be added to the new milk of the morning we may have such cheeses as the *Stilton* of England, or the small, soft and rich *Brie* cheeses, so much esteemed in France. If the entire milk only be used, we have such cheeses as the *Cheshire*, the *Double Gloucester*, the *Cheddar*, the *Wiltshire*, and the *Dunlop* cheeses of Britain. If the cream of the evening's milk be removed, and the skimmed milk added to the new milk of the next morning, such cheeses as the *Single Gloucester* are obtained. If the cream be taken once from *all* the milk, the better kinds of skim-milk cheese, such as the Dutch cheeses of Leyden, are prepared; while if the milk be *twice* skimmed we have the poorer cheeses of *Friesland and Groningen.* If skimmed for three or four days in succession, we get the hard and horny cheeses of Essex and Sussex, which often require the axe to break them up.

Again, new varieties of cheese are formed by mixing vegetable substances with the curd. A green decoction of two parts of *sage-leaves*, one of *marigold*, and a little *parsley*, gives its colour to the green cheese of Wiltshire. The celebrated *Schabzieger* cheese of

Switzerland is made by crushing the skim milk cheese after it is several months old to a fine powder in a mill, mixing it then with one-tenth of its weight of fine salt, and one-twentieth of the powdered leaves of the mellilot trefoil (*Trefolium meliotus cerulea*), and afterwards with oil or butter, working the whole into a paste, which is pressed and carefully dried.

Another variety of cheese is made by mixing one pound of sour milk with five pounds of boiled potatoes and a little salt, beating the whole into a pulp, which, after standing five or six days, is worked up again and dried. In Savoy an excellent potato-cheese is made by mixing one part of the pulp of potatos with those of *ewe milk* curd; and in Westphalia a potato-cheese is made with skimmed milk. This Westphalia cheese, while in a pasty state, is allowed to undergo a certain extent of fermentation before it is finally worked up with butter and salt, made into shapes, and dried. The extent to which this fermentation is permitted to go determines the flavour of the cheese.

In England cheese is often coloured with Spanish annatto, and accidents have been investigated in which *red lead* was found in the cheese examined, the eating of which had been productive of more or less severe illness; the poison was traced to an adulteration of the annatto employed to colour the cheese. Red lead is detected in cheese in the same manner as has been described in the article on *Blanc Mange*, p. 60.

Cheese, however, is, under certain circumstances, very unwholesome, even when it has not been adulterated, for it spontaneously undergoes changes which render it unfit as an article of food; indeed, most cheese has undergone a slight alteration of the kind now alluded to; and it is probably owing to this that cheese disagrees with so many persons; not because it is especially indigestible, but because the peculiar matter the cheese contains in its altered state has much more action on some persons than on others.

According to Dr. BRUCK, cheese can become poisonous under various circumstances, and this poisonous action is not the same with all persons. WESTRUMB places the poisonous principle of cheese under the narcotic-acid class. SERTUERNER, on analyising this article of food, showed that it could undergo a chemical decomposition giving rise to an essentially poisonous principle; and JULIA DE FONTENELLE and WITLING thought that cheese in its alteration became impregnated with hydrocyanic (prussic) acid, and that it was owing to this substance that certain cheeses owed their poisonous effects. This has, however, been shown by TAYLOR not to be correct.

The following analyses of cheese were performed in the laboratory of Professor JOHNSTONE * :—

Kind of Cheese	Centesimally represented				Remarks
	Water	Casein	Fat	Ash	
Skim milk . .	43·80	45·06	5·98	5·18	Made in Lanarkshire, on a poor, cold, wet, upland moor farm
Double Gloucester	35·82	37·96	21·97	4·25	
North Wilts. .	36·54	31·12	28·09	4·45	From a rich loam with gravel subsoil
Dunlop . .	38·46	25·87	31·86	3·81	
Cheddar . .	36·24	28·98	30·40	4·38	From a rich deep soil in the marsh near Cheddar

The inorganic constituents are only due in part to the milk. The earthy phospates attach themselves to the curd in the making, while the soluble parts remain principally in the whey. The cheese being cured with chloride of sodium, the quantity added varying with circumstances, the additional constituents of the ash are *lime*, a little *magnesia*, *soda*, *potassa*, traces of *iron*, *chlorine*, *phosphoric*, and *sulphuric* acids.

Fresh cheese is very sparingly dissolved by water; but after having been left to itself for two or three years, it becomes, especially if all the fat be previously removed, almost completely soluble, forming a solution which, like milk, is coagulated by the addition of acids.

The casein, which is insoluble when fresh, returns during the ripening to a state similar to that in which it existed in the milk. In the English, Dutch, and Swiss cheeses, and in the superior French kinds, the casein is present in its unaltered condition. The odour and flavour are owing to the decomposition of the butter, the non-volatile acids, *margaric* and *oleic*; and *butyric*, *valerianic*, *caproic*, *caprylic* acids, which are volatile, are liberated, in consequence of the decomposition of glycerin, and the variations in its pungency depend upon the proportion of the latter acids present. In the Limbourg cheese, the valerianic acid occurs in the largest quantity. BALARD first discovered it in the cheese of Roquefort.

The bad smell of inferior kinds of cheese is caused by certain fetid products containing sulphur, and which are formed by the putrefaction or decomposition of the casein. The alterations which the butter undergoes in becoming rancid, or which occurs in the milk-sugar still present being transmitted to the casein, effects a change in its composition and deteriorates its nutritive qualities.

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* See Muspratt's *Chemical Dictionary*, which contains an excellent article on the preparation of various kinds of cheese.

CHICORY. *See* COFFEE.

CHILI SALTPETRE. *See* NITRE CUBIC.

CHLORATE OF POTASSIUM (Chlorate of Potash).—The chlorate of potassium met with in commerce is generally pure. Sometimes, however, it is contaminated by chloride of potassium. When pure, it has a cooling, austere flavour; it is in the form of flat crystals of a nacreous appearance.

The solution of pure chlorate of potassium is not rendered turbid by nitrate of silver, but if it contains any chloride of potassium, that reagent immediately produces a precipitate of chloride of silver, soluble in ammonia.

For the purpose of determining the quantity of *chloride of potassium* contained in the chlorate under examination, the test solution of nitrate of silver mentioned in the article on the assay of silver may be very conveniently employed. A given weight—100 grains, for example—of the chlorate should be dissolved in an adequate quantity of water, and the test-solution of nitrate of silver is poured from an alkalimeter into the solution of the chlorate, shaking or stirring it well after each addition of nitrate of silver; the operator stops when the last drop of the solution of nitrate of silver fails in producing a precipitate. The number of divisions employed indicates the quantity of chlorine, and consequently of chloride of potassium. 35·5 of chlorine represent 74·5 of chloride of potassium.

When chlorate of potassium is contaminated by *chloride of potassium,* the best way of purifying it consists simply in dissolving it in boiling water. On cooling, the chlorate of potassium crystallizes, whilst the chloride of potassium, being much more soluble, remains dissolved in the mother water.

CHLORIDE OF AMMONIUM. *See* SAL AMMONIAC.

CHLORIDE OF BARIUM.—Chloride of barium is seldom impure, yet it is sometimes contaminated by *chloride of strontium,* or by *nitrate of strontium,* or by *perchloride of iron,* in which case it has a yellow tinge; it is also occasionally contaminated by *chloride of calcium.*

Pure chloride of barium crystallizes in four-sided, flat, transparent prisms, which decrepitate when heated, and are not altered by exposure; they have a very bitter, pungent, and nauseous flavour; their specific gravity is 2.85.

The presence of *strontium* is detected by digesting a portion of the salt in alcohol and inflaming it, in which case the alcohol will then burn with a characteristic red flame.

The presence of *perchloride of iron* is indicated by the blue precipitate produced by testing the solution of the salt with ferrocyanide of potassium.

The presence of *chloride of calcium* is recognised first, because the salt is thereby rendered deliquescent; and by treating it with pure or absolute alcohol, the chloride of calcium is dissolved, but the chloride of barium is untouched. The whole is then thrown on a filter in order to separate the chloride of barium, the filtrate which contains the chloride of calcium is evaporated to dryness at a gentle heat; nitric acid is then added, and the liquor may now be tested for lime either by a mixture of sulphuric acid and alcohol, which will produce a precipitate of sulphate of calcium insoluble in aqueous alcohol; or, after having neutralized the liquor by ammonia, the addition of oxalic acid produces a precipitate of oxalate of calcium.

The solution of pure chloride of barium in distilled water should be perfectly clear and limpid; it should not be acted upon or rendered turbid by ammonia, by hydrosulphate of ammonia, nor by sulphuretted hydrogen.

The addition of sulphuric acid should precipitate every fixed particle from it; so that, after separating the sulphate of barium thus produced by filtering, the filtrate, being evaporated in a platinum crucible, should not leave the slightest residuum.

CHLORIDE OF LIME (Hypochlorite of Lime, Bleaching Powder). *See* CHLORIMETRY.

CHLORIDE OF SODIUM (Common Salt, Muriate of Soda).—Common salt not being subject in this country to any fiscal tax, is exceedingly cheap, and accordingly is not adulterated, at least to any extent, the price of the article itself being as low, or nearly so, as that of the substances which might be employed for this culpable purpose.

Common salt, however, is often mixed with *water* in order to augment its weight; sometimes also it contains *sulphate* or *nitrate of calcium* or *of magnesium*, or the *chlorides of these metals*.

In the countries where a tax is put on this commodity, the adulterating substances employed, besides those above-named, are *sulphate of sodium, alum, earthy matter*, &c. These impurities may be detected as follows:—

When salt has been moistened with water in order to augment its weight, its appearance sufficiently indicates the adulteration; but in order to determine the quantity of the water it is necessary to weigh a certain quantity of the salt—for example, 1,000 grains—previously reduced into fine powder, and expose it in a porcelain dish or capsule to the heat of a steam-bath until the weight remains constant. The loss indicates the quantity of water, and if that quantity exceeds from 6 to 8 per cent., it is due either to a direct admixture of water, or to the presence of deliquescent salts.

Sulphate of calcium is easily detected in common salt by its insolubility in water, especially if alcohol be added. The insoluble sulphate of calcium may then be collected on a filter, washed with dilute alcohol, dried and weighed.

If *soluble sulphates* are present, a solution of chloride of barium will at once produce a precipitate of sulphate of barium. For example :—In order to detect the presence and determine the amount of *sulphate of sodium* in common salt, dissolve 1,000 grains of the salt under examination in distilled water, filter the liquor, wash the filter, and add to the filtrate a solution of chloride of barium, until a precipitate is no longer produced. The whole is then left at rest, in order to allow the precipitated sulphate of barium produced to settle. This being done, the clear supernatant liquor is decanted, and the precipitate is collected on a filter, washed thereon with boiling water, dried, ignited in a platinum crucible, and weighed. 117 of sulphate of barium represent 40 of sulphuric acid, and consequently 72 of anhydrous sulphate of sodium, or the equivalent of any other sulphate.

But as common salt often contains naturally a small quantity of *sulphate of sodium,* which however does not exceed one per cent. in the average, it is only when the quantity exceeds that amount that fraud may be suspected.

If any *soluble earthy salts* are present, a solution of carbonate of sodium poured in the solution of the salt under examination will produce a precipitate, the amount of which may be determined by weighing, after previously washing and drying it.

If the salt under examination contain any *carbonate,* its presence may be immediately detected by the effervescence which is produced upon pouring an acid (dilute hydrochloric acid, for example) upon a portion of the salt. The proportion of the carbonate present may be determined in the manner described in the article on Alkalimetry. (See *Alkalimetry.*)

Sixty grains of pure salt should be exactly precipitated by 170 grains of nitrate of silver, and the precipitate so produced, being washed, dried, and carefully fused, should weigh 144 grains.

Chloride of sodium (common salt) may also be analyzed by means of the alkalimeter, with a test-liquor of nitrate of silver, as described in the article on the assay of the silver in the wet way. (See *Silver.*)

CHLORIMETRY.—Chlorimetry is the name given to the processes employed for ascertaining the strength or commercial value of substances containing chlorine, or from which chlorine may be produced. Chloride of lime, chloride of potash, and chloride of soda, are the most important of these substances; *chloride of lime* is a mixture of hypochlorite of calcium, chloride of calcium, and hydrate of lime. It undergoes very great deterioration by exposure to the air, and may thus become perfectly valueless; for it gradually loses chlorine and becomes converted into carbonate of calcium.

This deterioration is common to all other decolorizing chlorides, which are likewise decomposed by all acids, even by carbonic acid.

The value of chloride of lime depends altogether upon the quantity of chlorine which it contains and which may be liberated. For technical purposes this estimation is exceedingly important, and should never be neglected by the bleacher.

(1) *Modification of the Method of Gay-Lussac.*—This is founded on the conversion of *calomel* (subchloride of mercury) into corrosive sublimate (chloride of mercury) by the chlorine set free from the bleaching-powder. A fluid is prepared, holding in suspension a known quantity of subchloride of mercury; into this a measured quantity of the solution of chloride of lime to be tested is poured, until the liquid becomes perfectly clear. The quantity of chlorine consumed, and consequently the value of the bleaching-powder, calculated from the number of divisions of the burette which have been required to render the turbid mixture clear.

Preparation of the Standard Mercurial Test Liquor.—It is based on the following considerations:—

Every 236·5 grains of subchloride of mercury require 35·5 grains of chlorine to convert them into chloride; every 58·5 grains of common salt (which is the chloride most convenient for the purpose) contain 35·5 grains of chlorine, or 164·7 grains contain 100 grains of chlorine.

Let 50 measures of a solution of a subsalt of mercury—the subnitrate, for example—be introduced into the graduated burette, and then poured off into a beaker, and diluted with 4 or 5 ounces of water; then let 82·4 grains of common salt be dissolved in water and introduced into the burette, so as to exactly fill 100 measures. Let this solution be poured gradually into the solution of the subnitrate (which during the time should be kept warm by immersion in a basin of hot water), until the last drop added no longer produces a precipitate. Let us suppose that 20 measures have been required; now, as 100 measures of the saline solution contain 82·4 grains of chloride of sodium = 50 grains of chlorine, the 20 measures must contain 16·48 grains = 10 of chlorine. We consequently arrive at the conclusion that 50 measures of the subnitrate of mercury require 10 grains of chlorine to convert the salt into subchloride; and if the 50 measures are increased to 100 by dilution with water, a solution is obtained every 10 divisions of which are equivalent to 1 grain of chlorine, and every single division of which represents $\frac{1}{10}$th of a grain. Any quantity of the test liquor may thus be easily prepared.

Method of testing the Bleaching-powder.—100 grains of the specimen, selected from different parts of the sample, and well mixed together, are rubbed in a mortar with a little water; more water is gradually added, the mixture stirred, and the heavier particles allowed to subside; the milky fluid is then poured off, and the precipitate again agitated with water, allowed to stand, and the supernatant fluid poured off, mixed with the first, and transferred to a tube graduated into 200 equal parts, each part corresponding with a division of the burette; the mortar is rinsed out with a little more water, the washings transferred to the graduated tube, the whole well agitated, and the mark at which the solution stands in the tube is accurately noted. Suppose the whole to occupy 150 measures. The burette is now filled to 100 with the mixture. Next, 100 measures of the standard subnitrate of mercury are poured into a beaker and diluted with water, excess of common salt is added to the solution, which is then acidified with pure hydrochloric acid. The well-agitated solution of chloride of lime is then dropped gradually into the newly-formed calomel in the beaker, until it is perfectly clear, by which it is known that the whole of the calomel has been converted into corrosive sublimate. It must be constantly stirred while the bleaching solution is being added, and it is essential that it should remain acid during the whole time. Now, from what has been explained above, it is evident that the number of divisions of the bleaching solution that have been consumed in rendering the turbid mercurial salt clear must correspond with 10 grains of chlorine. Suppose 65 measures were required, then the value of the specimen is found very simply by the following proportion:—

$$\text{As } 65 : 10 :: 150 : x,$$

$x = 23{\cdot}07$ = the quantity of chlorine in 100 grains of the bleaching-powder.

It is evident that any other proportions than those here given may be employed, both in making the standard mercurial solution, and in performing the analytical process. The above must be regarded as merely an illustration of the principles of the operation. This method is found to yield very accurate results. There is perhaps one disadvantage attending it, which is, that the solution of subnitrate of mercury is somewhat liable to change, and to give rise to the formation of an insoluble basic salt, which would of course interfere with its accuracy.

(2) *Modification of Gay-Lussac's Method by Arsenious Acid.*—When arsenious acid, water, and chlorine are brought into contact with each other, a reaction takes place, the result being the formation of hydrochloric and arsenic acids.

Every equivalent (or 99 parts) of arsenious acid require two equivalents (or 71 parts) of chlorine; consequently 100 parts of chlorine are required to convert 139·45 parts of arsenious acid into arsenic acid. A standard solution of arsenious acid is prepared by dissolving 139·45 grains of the pure acid in a solution of potassa, diluting the solution, and then adding hydrochloric acid in considerable excess; the volume of the solution is then brought to 10,000 grain-measures, and the whole well mixed; every 100 grain-measures of the solution thus prepared contain 1·395 grains of arsenious acid = 1 grain of chlorine. When the chlorimetric assay is about to be made, 50 grains of the bleaching-powder are prepared in the manner already described, and the burette is filled to the 100th division with the solution; 1000 grain-measures of the arsenious acid are then placed in a beaker, diluted with water, and coloured blue by the addition of a few drops of solution of indigo. The bleaching liquid is then gradually and carefully dropped into the arsenical solution, which is all the time well stirred until the blue tinge is entirely destroyed. This shows that the conversion of the arsenious acid into arsenic acid is complete, and consequently that 10 grains of chlorine have been consumed, and, as before, the value of the bleaching-powder is ascertained by the rule of simple proportion: thus, supposing 90 measures have been consumed, then—

$$\text{As } 90 : 10 :: 100 : x,$$

$x = 11{\cdot}11$ = the quantity of chlorine in 50 grains of the bleaching-powder, or 22·22 per cent.; or still more simply, as each measure of the burette corresponds with half a grain of bleaching-powder, and as the number of measures consumed contain 10 grains of chlorine, we find at once the percentage amount of chlorine, by dividing 2000 by the number of measures required; thus:—

$$\frac{2000}{90} = 22{\cdot}22.$$

(3) *Otto's Method by Protosulphate of Iron.*—When protosulphate of iron, water, chlorine, and free sulphuric acid are brought

into contact, a reaction takes place, resulting in the formation of hydrochloric acid and persulphate of iron.

Every two equivalents, or 152 parts of anhydrous, or 278 parts of crystallized protosulphate of iron, require one equivalent, or 35·5 parts of chlorine; 100 grains of chlorine are therefore required to convert 783·1 grains of crystallized protosulphate of iron into persulphate. To prepare the iron salt for these experiments, FRESENIUS directs that iron nails free from rust be dissolved in dilute sulphuric acid, finally with the application of heat; the solution is filtered while still warm, into about twice its volume of spirits of wine; the precipitate which is produced consists of protosulphate of iron with seven equivalents of water. It is collected on a filter, edulcorated with spirits of wine, spread upon a sheet of blotting-paper, and allowed to dry in the air until it has completely lost the smell of spirits of wine: the dry salt must be kept in a well-closed bottle. To perform the chlorimetric assay, 78·3 grains of the protosulphate are dissolved in about two ounces of water, and the solution strongly acidulated with sulphuric acid; 50 grains of the bleaching-powder are then prepared as before directed, and the burette filled with the solution, which, after being well agitated, is added drop by drop to the solution of the iron salt until complete peroxidation has taken place; this is known by solution of ferricyanide of potassium no longer striking a blue precipitate. The best way of testing the solution from time to time is to cover a large white plate with drops of the ferricyanide solution, and, as the operation draws towards an end, to convey a minute drop from the solution, at the end of a small stirring-rod, to one of the drops; the process is complete when prussian blue ceases to be formed, a green colour being produced in its stead. The number of divisions of the burette which have been consumed is now noted; this corresponds with 10 grains of chlorine, that being the quantity required for the peroxidation of 78·3 grains of crystallized protosulphate of iron. The calculation is precisely the same as in the last method.

(4) *By Ferrocyanide of Potassium.*—When ferrocyanide of potassium is brought into contact with free chlorine, a reaction takes place, resulting in the production of *ferricyanide* of potassium and chloride of potassium. Every two equivalents, or 368 parts of anhydrous, or 422 parts of crystallized ferrocyanide of potassium, require one equivalent, or 35·5 parts of chlorine; 100 grains of chlorine, therefore, are required to convert 1188·7 grains of crystallized ferrocyanide of potassium into ferricyanide, or 118·87 grains correspond to 10 grains of chlorine. The experiment is conducted in precisely the same manner as before, and as soon

as the whole of the ferrocyanide is converted into ferricyanide, the mixture ceases to give prussian blue with a solution of peroxide of iron.

Dr. C. R. A. Wright has found the bleaching-powder of commerce to contain several per cents. of *chlorate of calcium*, even when newly made; in other samples the chlorate has been occasionally found to represent as much as 10 per cent. of available chlorine, or fully one-fourth of the amount originally present, thus indicating over heating, either in the process of manufacture or subsequently. In such bleaching-powders the only safe and convenient method is by the use of an alkaline solution of arsenious acid.

The following modification of Otto's method is based on the fact that under the conditions described the chlorine of the bleaching-powder first changes the protochloride of iron into *perchloride*, which in its turn is again reduced to protochloride by metallic copper, whereby some of the latter becomes dissolved. Every 2 equivalents of copper dissolved in this way is equivalent to 1 equivalent of chlorine in the bleaching-powder. Two grammes of the bleaching-powder are well mixed with water, and the fluid so obtained mixed with a solution of protochloride of iron, freshly made by dissolving 0·6 grm. of pure iron wire in pure hydrochloric acid; excess of acid is then added, and the fluid boiled in a flask, after addition of a piece of rather thick, perfectly clean and polished *sheet copper* of a weight of about 4 grammes. The boiling is continued until the colour of the fluid, at first darkish, has become bright green; the copper is then removed from the flask, washed with distilled water, dried, and weighed. A loss in the weight of copper of 63·4 parts (=2 copper) is equal to 35·5 parts of chlorine in the bleaching-powder.

CHLOROFORM.—Among the substances occasionally found adulterating chloroform, are *alcohol*, *aldehyde*, free *hydrochloric* and *hydrochlorous* acids, and some of the compounds of *methyl*. The following is the mode of detecting these impurities adopted by Dr. Letheby:—

'*Alcohol* is often recognised at once by the milkiness of the liquid. If it exists to the extent of from 30 to 50 per cent., the specific gravity of the sample falls much below 1·496; and when a drop of it is let fall into a little water, instead of sinking as a clear pellucid bead, it falls through the water as an opaque pearly drop. On shaking it in the water the mixture becomes milky, and it requires a long time for the chloroform to subside perfectly. After it has done so, it may be observed that the original bulk of the chloroform has diminished; in fact, the alcohol has been dissolved out of it, and it has shrunk accordingly. In this way we can often determine the amount of the alcohol present. Take, for example, about 30 drops of the suspected chloroform, put it into a narrow test-tube, mark the level at which the liquid stands, then add about 2 drachms of distilled water, and shake them well together. On allowing them to rest for an hour or so, the chloroform will collect at the bottom of the liquid, and we can then discover, from the diminution in its bulk, the amount of alcohol dissolved.'

Dr. LETHEBY thinks that much of the chloroform now used in America is contaminated with alcohol; for, according to the report of Professor MEIGS, it has the low sp. gr. of 1·450; and he puts it whether this may not be one of the reasons for the unsatisfactory accounts which have come from that country.

Aldehyde is another substance which may be occasionally met with in chloroform. It is recognised by its reducing action on the hydrated oxide of silver, and by its rendering a little liquor potassæ of a brown colour when it is heated with it. It is questionable if it occasions any injurious influence when it is inhaled with the chloroform, but it is likely to be converted into acetic acid, and this is somewhat of an irritant.

In a sample of chloroform, which was furnished to the London Hospital, Dr. LETHEBY found as much as 53 per cent. of free hydrochloric acid, a quantity which, in its gaseous state, amounts to 500 per cent. of the bulk of the liquid chloroform. This sample, on attempting to use it, gave rise to the most distressing symptoms, occasioning cough, difficulty of breathing, a highly congested countenance, followed by rapid prostration of the vital powers, with almost complete collapse. If it had fallen into the hands of an inexperienced operator it would, without doubt, have produced fatal effects. Chloroform containing this acid has often an irritating odour. It reddens litmus-paper, and gives rise to a white precipitate when it is shaken with a solution of nitrate of silver.

Hypochlorous acid may be detected by its odour, by reddening and then partially bleaching a piece of litmus-paper, and by its giving a white precipitate with the solution of nitrate of silver.

Hydrochloric ether may sometimes be recognised in chloroform. It is discovered by shaking the chloroform with water, then decanting the latter and distilling it from a water-bath. The odour of the hydrochloric ether is very evident in the portions which first come over.

Compounds of Methyl.—It is to be regretted that these dangerous compounds are not to be detected very easily. One of the best signs of their presence is the effect which they produce upon the animal system. They occasion a peculiar throbbing headache, and a rapid prostration of the vital powers. These effects may often be observed when the chloroform is only smelled for a little while; and there can be little doubt that they are very frequently the cause of the discomfort which so often follows upon the use of certain samples of chloroform.

Pure chloroform should, according to SOUBERAIN, sink in a mixture of equal parts of sulphuric acid and water. The presence of alcohol may be detected by warming the chloroform with chromic acid, or with acid chromate of potassium and sulphuric acid; the production of a green colour indicates alcohol; moreover the presence of alcohol causes opalescence when the chloroform is mixed with water. Chloroform is sometimes prepared from wood-spirit, but it is much less pure than that prepared from alcohol; it is specifically lighter, has a repulsive empyreumatic odour, and produces unpleasant sensations when inhaled. It is contaminated with about 6 per cent of an empyreumatic oil, containing chlorine, burning with a smoky flame lighter than water, and boiling between 85° and 133° C.

According to GREGORY ('Proc. Roy. Soc. Edin.', 1850, p. 391) impure chloroform may be recognised by the disagreeable odour which it leaves after evaporation on a cloth which has been moistened with it, and by the yellow or brown colour which it imparts to pure oil of vitriol when agitated therewith. Pure chloroform placed upon oil of vitriol produces a contact surface convex downwards, impure chloroform gives a plane contact surface. According to ROUSSIN ('J. Pharm.' (3) xxxiv. 206) the purity of chloroform may be tested by means of *dinitrosulphide of iron*, a salt obtained by the action of ferric sulphate or chloride on a mixture of sulphide of ammonium and nitrate of potassium. Pure chloroform taken up with this salt remains colourless; but if it contain alcohol, ether, or wood-spirit, it acquires a dark colour. To purify chloroform GREGORY recommends to agitate it, and leave it in contact with oil of vitroil, but the latter is no longer coloured; the chloroform is then to be removed and placed in contact with a small quantity of peroxide of manganese to free it from sulphurous acid. According to ABRAHAM ('Pharm J. Trans.,' x. 24), chloroform thus purified quickly decomposes and is afterwards found to contain hydrochloric acid and free chlorine. According to CHRISTISON (*ibid.* x. 285), chloroform keeps well after being treated once with oil of vitroil, but the continued action of that liquid (especially if contaminated with nitrous acid) exerts a decomposing action upon it.

CHOCOLATE AND COCOA.—Chocolate is a preparation of the cocoa-nut, obtained by grinding the nuts, previously roasted and shelled, in an apparatus, which consists either of a flat stone with a steel cylinder, or of conical stone rollers revolving on a circular table of the same material, or of a mill of peculiar construction. The mill, or the stones, are heated to about 212° Fahr., and the roasted and shelled cocoa-nuts are submitted with sugar to the grinding operation, by which they are reduced into a syrupy mass, which is received into moulds of various shapes, in which it hardens in cooling.

Besides cocoa-nuts and sugar, the manufacturer generally adds some arrow-root, many persons preferring the chocolate so prepared, because the oil or butter of cocoa is thereby rendered emulsive and more digestible. The preparation known as *cocoa-powder*, or chocolate-powder, when genuine, consists only of cocoa-nibs, sugar, and arrow-root, mixed and ground together, and then pulverized, by passing the mass through a grating-mill, and cooling it.

Chocolate, as well as cocoa-powder or flakes, prepared as above said, is one of the most grateful, nourishing, and easily digestible articles of food; it belongs to the class of perfect alimentary substances. Unfortunately, however, many of the preparations of the cocoa-nut, sold under the name of chocolate, of cocoa-flakes, and of chocolate-powder, consist of a mixture of bad or musty cocoa-nuts, with their shells, coarse sugar of the very lowest quality, ground with potato-starch, old sea-biscuits, coarse branny flour, animal fat (generally tallow, or even greaves). Cocoa-powder has been met with made of potato-starch, moistened with a decoction of cocoa-nut shells, and sweetened with treacle; chocolate made with the same materials, with additions of tallow and of ochre.

Genuine chocolate is of a dark brown colour; that which has been adulterated is generally redder, though this brighter hue is sometimes given to excellent chocolate, especially in Spain, by means of a little annotto. This addition is unobjectionable, provided the annotto is pure, which, however, is not always the case. *See Annotto.*

Genuine chocolate should dissolve in the mouth without grittiness; it should leave a peculiar sensation of freshness, and after boiling it with water the emulsion should not form a jelly when cold; if it does, starch or flour is present. The admixture of flour, or of starch, moreover, may be readily detected by the blue colour which is imparted to the decoction, after cooling, by solution of iodine.

Brick-dust and other *earthy matters* are detected by incinerating a given weight of the chocolate or cocoa under examination; the impurities remain among the ashes, and may be easily recognized. This adulteration is also readily detected by grating 500 grains of the chocolate in as fine a powder as possible, throwing it into about half a pint of cold water, stirring the whole briskly for about ten minutes, leaving it at rest for about two minutes, and decanting the supernatant liquor. The earthy matter will then have subsided, and will be left as sediment.

The presence of *animal fats* may be detected by the palate, for the chocolate generally has, in that case, a cheesy flavour; or, when common butter or oil has been added, it has a rancid flavour. This is quite characteristic, for butter of cocoa always remains perfectly sweet.

The presence of *animal fats*, or of *oils*, may also be recognized by saponifying a portion of the chocolate as follows:—Rasp about 2,000 grains of the chocolate under examination, and boil them with water and some caustic potash. When the fat has saponified, dilute the mass with a sufficient quantity of water, and filter three or four times. The milky filtrate, which is in fact a solution of soap, should now be supersaturated with nitric acid; this will separate the fat, which will float on the liquor after cooling. It may then be collected on a filter, and on rubbing a small portion of it between the fingers, the odour will generally indicate its origin; but more effectually still, by heating it in a small capsule. Pure butter of cocoa has no odour.

Or the chocolate may be exhausted by sulphuric ether, and by evaporating it the fat will be left behind, and may then be identified as above described.

If the chocolate has been mixed up with the *ground shells* of the cocoa-nut, the use of the microscope is the best way of detecting it. Or, after having treated a given portion of the chocolate by ether, the residuum may be exhausted by hot water, which will extract all the soluble portions and leave again a residuum, in which the sharp spiculæ of the ground husks, if any be present, may be readily seen with the help of a magnifying-glass.

The presence of cocoa-nuts shells in chocolate appears to be injurious to health. Dr. Ure relates, in his 'Dictionary of Arts, Manufacturers, and Mines,' that samples of chocolate made at the Victualling Yard, Deptford, for the use of the Royal Navy, and manufactured by the Government Chocolate Mills, were sent to him for examination, by order of the Lords of the Admiralty, under the following circumstances:—

For some time the chocolate, it would appear, had been distributed to sailors and convicts for their breakfast, at the rate of one ounce daily, when several of the men complained of its producing sickness, vomiting, purging, and other illness, and a few cases terminated fatally. A careful examination of the chocolate failed in detecting any impurity or deleterious substance, except that some gritty matter, incapable of mixing with water, and which, on closer examination, was found to consist of minute spiculæ of the cocoa-bean husks, which, when swallowed, became lodged in the villous coat of the stomach and bowels, where they created irritation and all the symptoms certified by several naval surgeons. It was obvious, observes Dr. URE, that from the insoluble condition of the chocolate, it could be of little use as an article of food, or as a demulcent substitute for milk; and that, in fact, three-fourths of it were, on this account, an ineffective article of diet, or were wasted.

In France, the chocolate-paste has usually a little vanilla incorporated with it, and a considerable quantity of sugar, which varies from one-third of its weight to equal parts, and one pod of vanilla is said to be sufficient to flavour one pound and a half of chocolate. Pure genuine chocolate improves in its flavour by keeping, which is the reverse with bad or adulterated chocolate; but the roasted beans soon lose their aroma if left exposed to the air.

CHROMATE of LEAD (Chrome Yellow, Cologne Yellow).—Chromate of lead is a fine yellow pigment, which, as found in commerce, is often adulterated with *sulphate of lead*, *sulphate of barium*, *sulphate of calcium*, sometimes to an enormous extent. *Carbonate of lead and of calcium* have also been used for that purpose; but as on treating the chromate of lead, adulterated with the latter substances by an acid, an effervescence is immediately produced, betraying the presence of a carbonate, this fraud may be at once detected. This, however, is not the case with either sulphate of barium, or of lead, or of calcium, and these substances accordingly are almost exclusively employed for that purpose, especially sulphate of calcium, which is said to render the yellow colour of the chromate more vivid and more mellow at the same time. The pigment sold under the name of *Cologne yellow* consists of 25 parts of chromate of lead, 15 of sulphate of lead, and 60 of sulphate of calcium.

The presence of *sulphate of calcium* may be detected in the following manner:—A portion of the suspected chromate is first reduced to fine powder, and thoroughly mixed with one-fourth of its weight of finely pulverized charcoal, and the whole is to be calcined in a covered crucible. Under this treatment the sulphate of calcium, if any be present, will be converted into sulphide of calcium, and on treating the residuum with dilute muriatic acid, a disengagement of sulphuretted hydrogen will take place, easily recognizable by its odour (that of rotten eggs). The whole should then be thrown upon a filter, and to the filtrate, which has a green colour, ammonia is added, which will precipitate all except the lime. The whole is again thrown upon a filter, and if oxalate of ammonium be now poured into the filtrate, an abundant precipitate of oxalate of calcium will be produced.

The analysis of chromate of lead may be performed as follows:—Having first reduced the chromate of lead into very fine powder, hydrochloric acid is poured upon it, and the whole is boiled, alcohol being added at the same time, in order to convert the chromate of lead into chloride of chromium which remains in solution, and into chloride of lead, which remains in an insoluble state, along with any sulphate of lead, of calcium, or of barium which may be present. These insoluble substances are collected on a filter, washed with dilute spirits of wine, dried, and weighed. The filtrate which contains all the chloride of chromium is then boiled, and ammonia is poured into the hot liquor and heated with the ammonia until the whole of the chromium is precipitated in the state of hydrate of oxide of chromium; the supernatant liquor is then colourless. This hydrate is collected on a filter, washed, dried, and carefully ignited in a well-closed platinum crucible, and then weighed. 40 grains of oxide of chromium = 52 of chromic acid, and consequently 164 grains of chromate of lead.

Supposing, therefore, the chromate of lead submitted to analysis to have been pure—since 164 grains of chromate of lead contain

Oxide of lead	112
Chromic acid	52
	164

The results obtained by the analysis of that quantity should be—

40 grains of sesquioxide of chromium precipitated by ammonia, corresponding to chromic acid		52 grains.
140 grains of chloride of lead, insoluble in dilute alcohol, consisting of		
Lead	104	
Chlorine	36	
	140	

And corresponding to oxide of lead . . .	112
Chromate of lead . .	164

Consequently, if the quantity of chromate of lead submitted to examination was, for example, 25 grains, the operator should obtain on the one hand

Sesquioxide of chromium . .	6·09 grains.
Chloride of lead	10·00 ,,

Or, in other words, each grain of chromate of lead operated upon should yield 0.24 grain of oxide of chromium, and 0.4 grain of chloride of lead.

Before treating the chromate of lead by hydrochloric acid, it should be reduced into extremely fine powder by levigation; if this precaution be neglected, some portions may escape decomposition.

Chromate of lead has sometimes been adulterated with *starch*, but this fraud may be readily estimated by the loss which it sustains when strongly calcined in a crucible, an odour of burning vegetable matter being perceptible during the ignition.

CHROMATE OF POTASSIUM.—Neutral chromate of potassium is an important salt used for the preparation of all the other chromates, and especially that of lead. Pure chromate of potassium crystallizes in regular rhomboedrons; but as it is an easily efflorescent salt, it often forms a saline mass of a lemon-yellow colour. It has a bitter, disagreeable taste, and is very soluble in water.

A salt is sometimes met with in commerce under the name of chromate of potassium, but which is composed of 56·7 of sulphate of potassium, and 43·3 of chromate of potassium. This spurious article when in crystals may be at once recognised, because its crystals are in four or six-sided prisms, terminated by four or six-sided pyramids, whilst the pure chromate of potassium is in regular rhomboedrons, without pyramids.

But when in efflorescent masses, this adulteration cannot be thus detected, and therefore it must be analyzed, which may be done as follows:—

A given weight—50 grains, for example—of the salt are to be dissolved in water, and a solution of nitrate of barium is poured into the solution of the chromate until it no longer produces a precipitate. The precipitate so produced is yellowish white, and consists of chromate and of sulphate of barium. By treating this precipitate with nitric acid, the chromate of barium is redissolved, but not so the sulphate of barium, which being insoluble both in acids and in water, may be collected on a filter, washed, dried and weighed. 117 grains of sulphate of barium represent 40 grains of sulphuric acid, and consequently 88 grains of sulphate of potassium.

If, on the other hand, the operator should wish to determine the quantity of the chromate of potassium, he may do so by adding an excess of sulphuric acid to the liquor filtered from the sulphate of barium, in order to precipitate the excess of baryta which exists in the solution, and, after filtering the liquor, the oxide of chromium may then be precipitated by means of ammonia, collected on a filter, washed, dried, carefully ignited in a well-closed platinum crucible, and weighed. 40 grains of oxide of chromium represent 52 grains of chromic acid, and consequently 100 grains of neutral chromate of potassium.

Or the operator may at once proceed to estimate the quantity of chromate of potassium in the suspected sample by dissolving a given weight of it in a small quantity of water, adding a pretty large proportion of muriatic acid with alcohol, applying heat until the whole of the alcohol has evaporated; after which the oxide of chromium may then be precipitated by ammonia, filtered, washed, carefully ignited, and weighed.

CHROME IRON ORE (**Chromated Iron**).—Chrome iron ore is a combination of oxide of chromium with peroxide of iron and alumina, in which the proportion of oxide of chromium varies from 39 to 53 per cent., that is, in the well prepared ore; and this large proportion of oxide of chromium renders it a highly valuable ore.

Analysis of Chrome Ores.—Eight or ten grains of the ore reduced to an impalpable powder are put into a platinum crucible, and covered with ten or twelve times the weight of bisulphate of potassium; the crucible is carefully heated for about fifteen minutes to about the temperature of the fusing-point of the bisulphate, then raised to low redness, at which temperature it is kept for another quarter of an hour; the mass enters into quiet fusion, and vapours of sulphuric acid are evolved freely. The temperature is gradually raised until the whole is in perfect fusion. To the fused mass about 50 grains of pure carbonate of sodium are added, and the mixture is again fused at as low a temperature as possible, pure nitre being added by degrees in quantity equal to that of the carbonate of sodium. The crucible is kept at a low red-heat for about an hour, and then raised to a bright red-heat, at which it is kept for a quarter of an hour longer. When cold the fused mass is dissolved in boiling water, filtered whilst boiling hot, and the residue on the filter washed with boiling water. If this residue should contain any undecom posed ore, it must be again fused as before with bisulphate of potassium, carbonate of sodium, and nitre. The filtrate contains the whole of the *chromium* as *chromate of potassium*, together with small quantities of *silicic acid*, *alumina*, and sometimes *titanic* and *manganic acids.* Excess of nitrate of ammonium is added, and the solution is evaporated nearly to dryness on the water-bath, until all the liberated ammonia has been expelled ; water is added, and the precipitate, if any, is filtered off: the filtrate is made strongly acid with *sulphurous acid,* carefully heated to boiling, precipitated with slight excess of ammonia boiled for a few minutes and filtered. The thorough washing of the chromic oxide is not easy. GENTH ('Chem. News,' No. 137) finds it succeed best in the following way:—After the precipitate has settled, the clear liquid is passed through the filter ; then boiling water is added to the precipitate, and after settling, the supernatant liquid is filtered ; the precipitate is then thrown on the filter, and washed two or three times with boiling water ; it is then washed back again into the dish, and boiled with water, until the little lumps which clog together are completely broken up ; it is then filtered, and this operation is repeated until the wash-waters do not show the presence of any sulphates by chloride of barium. The precipitate is then dried and burned, after which it is again boiled with water, to which a few drops of sulphurous acid have been added, then ammonia added, and the precipitate washed, dried, ignited, and weighed. By this mode of analysis Dr. GENTH states that the chromic oxide is obtained quite pure, and that two analyses of the same sample will not, if the process be carefully conducted, vary more than 0·25 per cent.

Volumetric Valuation of Chrome Iron Ore (*Blodget Britton,* CROOKES'S 'Select Methods of Chemical Analysis').

Reduce the mineral to the finest state of division possible in an agate mortar. Weigh off 0·5 grm. and add to it a flux previously prepared, composed of one part chlorate of potassium and three parts soda lime ; thoroughly mix the mass by trituration in a porcelain mortar, and then ignite in a covered platinum crucible at a bright-red heat for an hour and a half or more. The mass will not fuse, but when cold can be turned out of the crucible by a few gentle taps, leaving the interior of the vessel clean and bright. Triturate in the mortar again, and turn the powder into a tall 4-oz. beaker and add about 18 c.c. of hot water, and boil for two or three minutes : when cold, add 15 c.c. of hydrochloric acid of common strength and stir with a glass rod for a few minutes, til the solid matter becomes dissolved. Both the iron and the chromium will then be in the states of sesquioxide of iron and chromic acid. Pour the fluid into a white porcelain dish of about 20-oz. capacity and dilute the washings of the beaker to about 3 oz. Immediately after also pour cautiously into the dish one gramme of metallic iron of known purity previously dissolved in dilute sulphuric acid, and further diluted with cold water to about 5 oz. to make up the volume in the dish to about 8 oz.

Use for this purpose fresh borings from a piece of bar iron containing less than 0·05 of foreign matter dissolved in 18 c.c. of dilute sulphuric acid of 1 part acid and 3½ parts water in a tube 12 inches long and ⅞ths of an inch diameter, closed at the top with an india-rubber stopper perforated for a ¼-inch tube bent short round at right angles, and extending horizontally about 3 or 4 inches, applying heat to expel atmospheric air and facilitate operations.

When the iron is dissolved, and having ascertained that the solution is freed from sesquioxide, nearly fill the tube with *cold* water, cautiously pour the contents into a dish, and add about two tubes full more of cold water to make the solution up to about 8 oz., and then determine volumetrically (*see* IRON), with a standard solution of permanganate of potassium, the amount of protoxide of iron remaining. The difference between the amount of iron found and of the iron weighed will be the amount oxidized to sesquioxide by the chromic acid. Every one part so oxidized will represent 0·320 of metallic chromium or 0·4663 of sesquioxide, in which condition the metal usually exists in the ore.

CHROMO-YELLOW. *See* CHROMATE OF LEAD.

CHRYSOCAL. *See* BRASS.

CHRYSOCOLLA. *See* BORAX.

CINNABAR. *See* VERMILION.

CITRIC ACID.—Citric acid is colourless and crystallizes in rhomboedral prisms, very soluble in water, and of a very sour flavour. It is not altered by exposure to the air; it is now manufactured in large quantities for the use of calico-printers. Its specific gravity is 1·034. The aqueous solution of citric acid is speedily altered by exposure.

Citric acid is sometimes adulterated with *tartaric acid.* In order to detect this fraud it is customary to dissolve a given weight of the acid in water, and to add gradually thereto a solution of hydrate or of carbonate of potassium, stirring the whole briskly, which produces a precipitate of bitartrate of potassium. If, however, the quantity of tartaric acid present is small, these reagents may fail in indicating it, because bitartrate of potassium is readily soluble in a slight excess of hydrate, or of carbonate of potassium. It is therefore better to employ a saturated solution (in the cold) of chloride of potassium, or of nitrate of potassium, or of neutral sulphate of potassium, an excess of which does not interfere with the precipitate of bitartrate of potassium, which will be formed if tartaric acid is present. It should be remembered that bitartrate of potassium is not an insoluble, but only a sparingly soluble salt, and therefore the solution of citric acid should not be dilute, for no precipitate would then appear.

If, however, the solution of citric acid is already dilute, it should be concentrated by evaporation; or, instead of the above named salts of potassium, acetate of potassium may be used in preference, for, being a deliquescent salt, it need not be dissolved previous to adding it to the solution of the citric acid.

Citric acid sometimes attracts moisture by exposure, which is a proof that it still retains a small proportion of the sulphuric acid used to prepare it, and the presence of which may besides be detected by dissolving a portion of it in water, and testing with solution of chloride of barium, which will in that case produce a white precipitate of sulphate of barium. In order to free it from this acid, it should be recrystallized several times.

COAL GAS.—The coal gas used for gas-light is a mixture of carbonic acid, carbonic oxide, hydrogen, and nitrogen, carburetted hydrogen, with vapours of hydrocarbons and olefiant gas; the illuminating power of the gas depends chiefly upon the quantity of the two latter substances contained in a given bulk of gas, but more especially upon the relative amount of the last named compound, the proportion of which however diminishes gradually as the operation of producing the gas at the works advances, until towards the end of the treatment of the charge in the retorts, the gas evolved contains a considerable quantity of hydrogen and of oxide of carbon, which burn with a faint blue and dimly luminous flame.

The same unfavourable result is obtained by increasing the heat of the retorts containing the charge of coals, the gas being thereby decomposed or decarbonised. But whilst the illuminating power of the gas evolved by such treatment is deteriorated, its *volume* or quantity is unfortunately increased.

Since chlorine has the power to form, by combining with olefiant gas and with the vapours of hydrocarbon, a peculiar oily liquid, the production of which is proportionate to the quantity of the above substances which may be present in the gas, it is clear that the diminution which a given volume of gas will suffer, after being mixed with chlorine, will at once give the amount of olefiant gas and of hydrocarbon vapour contained in that volume, and, consequently, indicate its illuminating power. This is easily done by filling a graduated jar, Fig. 15, of about an inch in diameter, with water, and then turning it upside down in a water-trough, so that, being filled with water, it may stand in the trough in the following manner:—

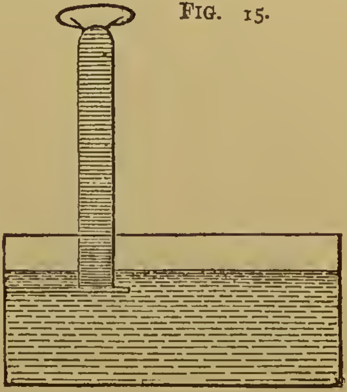


FIG. 15.

Transfer now the gas to be examined to the graduated jar until it is half full, and fill the other half of the graduated jar with pure chlorine gas, carefully protecting the mixture from solar light. Leave the whole at rest for twenty-four hours, and then observe the amount of condensation which will have taken place. The diminution of the volume of the gas first introduced into the jar will indicate very approximatively the proportion of olefiant gas in that volume.

For practical purposes the value or illuminating power of coal gas may be readily estimated by comparing the shadows projected upon a screen, such as a sheet of white paper, by the interposition of an opaque body between a wax candle, or any other flame, taken as a standard, and the jet of inflamed gas to be tested, and with which it has to be compared. The experiment is performed as follows:—

A sheet of unglazed white paper is to be pinned smoothly to a wall before the two lights whose relative illuminating power has to be tested, and between them and the sheet screen of white paper, and at a distance of about three inches from the latter, an iron rod, about the size of the little finger, is to be placed, taking care to dispose the lights in such a way that the two shadows of the rod upon the screen are contiguous. The rod should be previously blackened by holding it in the flame of a candle. If the two shadows are not of the same depth, or degree of blackness, one or the other of the two lights must be shifted towards the screen, or removed at a greater distance from it, until looking at the two shadows, by standing exactly opposite the paper screen, they appear to have the same degree of intensity. This point being hit, the relative intensity of the lights being directly as the square of their distance from the screen, their comparative illuminating power becomes known. Suppose, for example, that the jet of inflamed gas being at a distance of three feet from the screen, it is found that the wax candle requires to be moved towards the screen, at a distance of two feet therefrom, to obtain the same depth of shadow, the operator has only to square these numbers, and the difference expresses the proportion:—

$$3 \times 3 = 9; \ 2 \times 2 = 4.$$

The relative illuminating power of the two flames would then be in that case as 4 : 9. The flames to be compared should be placed at the same height.

Detection of Air in Coal Gas (CROOKES's 'Select Methods in Chemical Analysis').—Ten parts by weight of anhydrous sulphate of protoxide of manganese are put into a two-necked WOOLF's bottle, and twenty parts of warm water then added to dissolve it. To this mixture is immediately added a solution of ten parts by weight of Rochelle salt dissolved in sixty parts of water: the thorough mixing of the fluids is promoted by well shaking the bottle; after this a quantity of a solution of caustic potash is added, sufficient to render the fluid quite clear. Immediately after this perforated corks fitted with very tightly-fitting glass tubes are placed in the necks of the bottle, which should be entirely filled with the mixed fluid above described. One of the glass tubes—the inlet tube for the gas to be tested—should just dip a little under the upper level of the fluid: the outlet tube, on the other hand, should only reach half way the perforation of the cork. A very slow current of gas is now made to pass through the fluid, and kept going for at least a quarter of an hour and at most a full hour. If the gas be quite free from atmospheric air, the fluid in the bottle will remain quite clear; if *traces* even of air are present a faint colouration of the liquid will soon become apparent; with a larger proportion the fluid will soon be coloured first brown and afterwards intensely black. Since these changes of colour are due to the oxidation of the manganese, it is evident that every care must be taken to avoid the presence or access of accidental air. The fluid in the WOOLF's bottle should reach the cork.

Estimation of the Total Amount of Sulphur in Coal Gas.—The following simple method is employed by Dr. LETHEBY. The objects are to effect the combustion of the gas in a strongly ammoniacal atmosphere, by which means the sulphurous acid is fixed by the ammonia as soon as formed, and to condense the sulphite of ammonium. These objects are accomplished in the following way:—After passing the meter the gas goes through a bottle filled with pebbles moistened with dilute sulphuric acid, for the purpose of estimating any ammonia the gas may contain. The inlet pipe to this bottle is allowed to pass only one inch through the cork: the outlet pipe passes to the bottom of the bottle. The gas is thus forced through the pebbles from the top, which prevents any accumulation of salt about the inlet pipe. In place of this bottle, a tube about 6 inches long, an inch and a half in diameter, and drawn out at each end, may be used; it is filled, of course, with pebbles moistened with sulphuric acid, like the bottle, and may be placed horizontally. The gas thus purified from ammonia is consumed at the rate of about half a foot per hour in a LESLIE's burner, which is placed under a long funnel-shaped tube. This tube is connected to one end of a large glass cylinder. similar to those used for electrical machines, the other end of which is furnished with a piece of glass tube about 4 feet long, joined in such a manner that any products of combustion condensed in it will flow back into the large cylinder.

The means by which ammonia is supplied to the burner are the following:—A wide-mouthed bottle filled with the strongest liquid ammonia is placed immediately beneath the burner, and a funnel, with a short tin tube attached to it, is placed over the bottle in an inverted position. This short tube passes through the centre of the burner, so that the end of it is about 2 inches above the top of the flame. The draught produced through the whole apparatus when the burner is alight is sufficient to evaporate the ammonia in the bottle, which is discharged through the tube into the centre of the receiving-tube over the burner, and about 2 inches above the flame. Immediate combination then ensues between the ammonia and the sulphur products of the consumed gas, and the resulting *sulphite of ammonium* is condensed along with the water formed in the large cylinder. After pouring out the solution and rinsing out the cylinder and tubes, the sulphite is converted into sulphate of ammonium, and the sulphuric acid determined as sulphate of barium in the usual way.

With this apparatus it is only necessary to observe two precautions—to burn the gas very slowly, and to keep up the supply of ammonia. The latter is of the utmost importance.

Mr. VALENTIN has found that by passing a mixture of coal gas and air over spongy platinum and then over a layer of soda-lime, every trace of the sulphur is absorbed and arrested.

Valuation of Coal for the Production of Illuminating Gas (CROOKES's 'Select Methods in Chemical Analysis').—Take 100 grains of the coal in small lumps, so that they may be readily introduced into a rather wide combustion-tube; this is drawn out at its open end (after the coal has been put in), so as to form a narrow tube which is to be bent at right angles: this narrower open end is to be placed in a wider glass tube fitted tight into a cork, fastened into the neck of a somewhat wide-mouthed bottle, serving as tar-vessel (hydraulic main of the gas works).

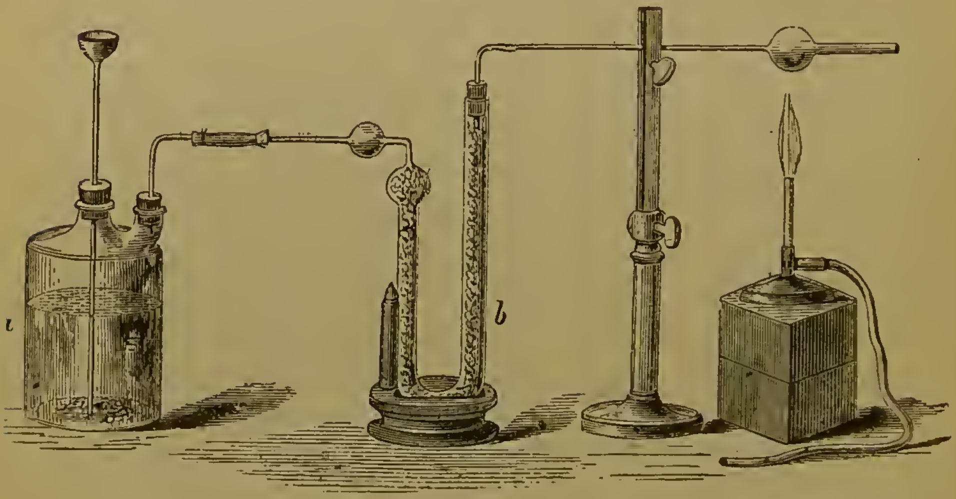
The cork alluded to is perforated with another opening, wherein is fixed a glass tube bent at right angles for conveying the gas first through a chloride of calcium tube, next through LIEBIG's potash bulbs, containing a solution of caustic potash, having oxide of lead dissolved in it. Next follows another tube, partly filled with dry caustic potash and partly with chloride of calcium; from this last tube a gas delivery leads to a graduated glass jar standing over a pneumatic trough, and acting as gas-holder. Before the ignition of the tube containing the coal is proceeded with, all the portions of the apparatus are carefully weighed, and next joined by means of india-rubber tubing. After the combustion is finished—which should be carefully conducted, so as to prevent the bursting or blowing out of the tube—the different pieces of the tube are disconnected and weighed again. The combustion-tube has to be weighed with the coal after it has been drawn out at its open end, and with the coke after the end of the combustion, when it is again cold, and for that reason care is required in managing it. We thus get the quantity of *tar, ammoniacal water, carbonic acid, and sulphuretted hydrogen* (as a sulphide of lead), and the gas is measured by immersing the jar in water, causing it to be at the same level inside and out. Empty the LIEBIG bulbs into a beaker, and separate the sulphide of lead by filtration, wash carefully, dry at 100° C., and weigh. From the sulphide of lead, the sulphuretted hydrogen present is calculated. This process, devised by the late Dr. T. RICHARDSON, of Newcastle-on-Tyne, was found by him to yield very reliable results, so as to be suitable for stating what quantity of gas a ton of coal analysed would yield.

COBALT ORES.—*Analysis of Cobalt Ores, containing Cobalt, Nickel, and Iron* (LIEBIG).—Add to the hot acid solution ammonia till slightly alkaline, then succinate or benzoate of ammonia to throw down the iron. Precipitate the filtrate by potassa, and filter. Wash the oxides of *cobalt* and *nickel* repeatedly; dissolve them in pure cyanide of potassium, then boil with an excess of fresh precipitated oxide of mercury. The whole of the nickel deposits with the excess of oxide of mercury. Filter, saturate with acetic acid; boil; then add sulphate of copper, and reboil. The precipitate has the following formula: $Cu_3Co_2Cy_6$. Collect it, and ignite, to destroy the cyanogen; dissolve in aqua-regia, and separate the copper by sulphuretted hydrogen; this precipitate must be redissolved, and the oxide of copper precipitated by potass. From the amount of copper that of cobalt is calculated. Three equivalents of copper are equal to two of cobalt.

Extraction of Cobalt and Nickel from the Ore.—The following process is followed in a manufactory at Birmingham, the ore employed consisting principally of metallic sulpho-arseniurets, and containing generally about 6 per cent. of nickel and 3 per cent. of cobalt. The ore is mixed with a small quantity of carbonate of calcium and fluor-spar, and the whole is heated to a white-red heat in a reverberatory furnace: the mass fuses at this high temperature, and a slag is obtained floating on the surface of a fluid mass, of metallic appearance; the latter is let out of the furnace by a particular aperture, and watered, in order that it may be broken into fragments with greater facility. It has been ascertained from experience that when the slag is of a dull colour iron is present, but if its surface be black and brilliant it is free from that metal. The metallic mass is reduced to a very fine powder, which is calcined at a bright-red heat in a furnace, the temperature being graduated so as to avoid fusion, and constantly raked: a considerable quantity of arsenious acid is driven off. The air has free access to the mass, which becomes oxidized and diminished in weight. The calcination, which lasts for about twelve hours, is continued until no more white fumes are given off, and the residue is treated with hydrochloric acid, which dissolves nearly the whole of it: the liquid is diluted with water, and milk of lime and chloride of lime added to precipitate the iron and the arsenic; the precipitate, after being well washed, is thrown away. A current of washed sulphuretted hydrogen, generated from sulphide of iron and dilute sulphuric acid, is passed into the liquor until it is saturated: it is discontinued, when some ammonia, added to a sample of the filtered liquor, gives a black precipitate; if there was not an excess of sulphuretted hydrogen, the precipitate produced by ammonia would be green: the precipitate is washed and then thrown away, a current of sulphuretted hydrogen being passed into the wash-waters. The cobalt is then thrown down with a solution of hypochlorite of lime. The precipitate, washed, dried, and then heated to redness, is considered to be oxide of cobalt, and part is sent in this state into the market. Another portion is heated to a white-red; by this treatment the oxide losses in weight, but increases in density; it is sold as protoxide of cobalt. The liquid from which the cobalt has been precipitated is treated with milk of lime, which precipitates the nickel in the state of hydrate: this precipitate is washed, dried, and heated to redness; it is then mixed with charcoal, and, by means of a strong heat, reduced to the state of a spongy nickel, which is employed in the manufacture of German silver. The oxide of cobalt thus prepared is remarkably pure.

Reduction of Oxide of Cobalt to Reguline Cobalt.—The small bulb-tube of hard glass attached to the U-shaped chloride calcium tube *b* (Fig. 16) having been carefully weighed, a certain known quantity of the previously weighed oxide is introduced, and the weight of bulb-tube again accurately noted: a stream of hydrogen gas dried by passing through the U-shaped tube is then caused to flow through the apparatus from the flask *a*, and a flame applied to the bulb containing the oxide; the heat must at first be gentle, but it must gradually be raised to full redness, this high temperature being necessary to prevent the reduced metal from acquiring a pyrophoric property, which would cause it to inflame on coming in contact with atmospheric air; the hydrogen reduces the metallic oxide, giving rise to a proportional amount of water, which escapes in the form of steam. When it is seen that water no longer continues to form, the flame is removed from the bulb, and it is allowed to cool, while a stream of hydrogen still continues to pass over it; the bulb-tube is then again weighed, and from the amount of reduced metal obtained the quantity contained in the whole of the protoxide precipitated is calculated. If a sufficiently high temperature has not been employed, the reduced cobalt oxidizes at common temperatures, but if a full red-heat has been employed it absorbs oxygen very slowly.

FIG. 16.



Precipitation as Sulphide.—Sal-ammoniac is added to the solution, then slight excess of ammonia, and finally sulphide of ammonium as long as precipitation takes place; the resulting sulphide of cobalt is washed with water containing a little sulphide of ammonium, then digested with aqua-regia, and precipitated by potassa, precisely as sulphide of nickel. The hydrated oxide, after being washed, dried, and ignited, is reduced by hydrogen in the manner just described. Rose recommends that, in the presence of ammoniacal salts, cobalt should always be precipitated by sulphide of ammonium.

Separation of Oxide of Cobalt from Oxides of Nickel, Zinc, and Chromium.

(a.) *From Nickel.*—Several methods have been proposed by different chemists, but until recently Phillips's process was the one generally preferred, which is as follows:—

a. Method of Phillips.—Both oxides are dissolved in an acid, and the solution supersaturated with ammonia, having previously added a sufficient quantity of sal-ammoniac to prevent any precipitation from taking place; the solution, which has a sky-blue colour, is largely diluted with water, which should have been previously well boiled, to free it from atmospheric air: caustic potassa is added to the hot solution, and the vessel is closed with a cork; *oxide of nickel* is precipitated, and *oxide of cobalt* remains in solution; when the former has completely settled, the supernatant liquid, which should have a rose-red colour, is poured through a filter, and the oxide of nickel washed with hot water, ignited, and weighed; the oxide of cobalt in the filtrate is precipitated by sulphide of ammonium. The reason why it is necessary to dilute the solution of the two oxides with water, free from atmospheric air, is, that oxide of cobalt in an ammoniacal solution is converted into peroxide of cobalt, which, precipitating as a black powder, would contaminate the oxide of nickel. The more dilute the solution is, the less easily does the oxide of cobalt become oxidized. When a large quantity of ammoniacal salt is present, the quantity of caustic potassa required to precipitate the oxide of nickel is very considerable. According to FRESENIUS, the separation by this method is not complete, the cobalt invariably containing traces of nickel, and the precipitated nickel often traces of cobalt.

β. Liebig's Method.—This is founded on the following considerations:—When any salt of cobalt is warmed with cyanide of potassium and an excess of hydrocyanic acid, it is converted into the *percyanide of cobalt* and *potassium*, or *cobalticyanide of potassium* ($Co_2\ Cy_6\ K_3$), the aqueous solution of which does *not* undergo any decomposition by boiling with either of the mineral acids. On the other hand, the precipitate produced by cyanide of potassium in solutions of salts of nickel is redissolved by cyanide of potassium, but the solution *is* decomposed by dilute sulphuric acid, cyanide of nickel being precipitated. When, therefore, a mixture of a cobalt and a nickel salt containing free acid is treated with excess of cyanide of potassium, and slightly warmed, we obtain in solution the double cyanide of nickel and potassium, and cobalticyanide of potassium $(\mathrm{Ni\,Cy} + \mathrm{K\,Cy}) + (\mathrm{Co_2\,Cy_6\,K_3})$, and, on adding the dilute sulphuric acid in the cold, three cases present themselves.

I. If the cobalt and nickel exist in the solution in the proportion by weight of *two* cobalt to *three* nickel, we have in the solution, $3\,(\mathrm{Ni\,Cy,\,K\,Cy}) + (\mathrm{Co_2\,Cy_6\,K_3})$, and the three equivalents of nickel replacing the three equivalents of potassium in the cobalticyanide of potassium, produce cobalticyanide of nickel $(\mathrm{Co_2\,Cy_6\,Ni_3})$, which is precipitated of a bluish-white colour, leaving in the solution no trace of either cobalt or nickel.

II. If the solution contain *less* nickel than corresponds to the above proportions, a certain quantity of cobalticyanide of potassium remains in solution, while cobalticyanide of nickel is still precipitated.

III. If the solution contain *more* nickel than corresponds to the above proportions, cobalticyanide of nickel is still precipitated, together with the excess of cyanide of nickel, which, by long boiling with hydrochloric acid, is completely converted into chloride of nickel, which remains in solution.

Now cobalticyanide of nickel, though insoluble in hydrochloric acid, is decomposed by boiling with caustic potassa into protoxide of nickel and cobalticyanide of potassium, thus, $\mathrm{Co_2Cy_6Ni_3} + 3\,\mathrm{KO} = \mathrm{Co_2Cy_6K_3} + 3\,\mathrm{NiO}$, and chloride of nickel is also decomposed by caustic potassa into protoxide of nickel and chloride of potassium. Hence, the following method of analyzing mixtures of cobalt and nickel, which is applicable to all proportions.

Hydrochloric acid is added to the solution of the metals, and then cyanide of potassium in such excess that the precipitate at first formed is redissolved; the whole is boiled, adding from time to time hydrochloric acid, until hydrocyanic acid ceases to be evolved. Caustic potassa is then added in considerable excess, and the boiling continued until the hydrated protoxide of nickel is completely precipitated; it is then filtered; the filtrate contains the whole of the cobalt in the form of cobalticyanide of potassium; it is evaporated to dryness with excess of nitric acid, the residue fused, and treated with hot water: peroxide of cobalt remains, which is dissolved in hydrochloric acid, and the solution treated as already directed.

When a mixture of the two oxides is dissolved in hydrocyanic acid and potassa, and the solution kept boiling in a flask, the cobalt becomes converted into cobalticyanide of potassium, and the nickel into protocyanide of nickel and potassium; all the cyanogen is extracted from the latter by *oxide of mercury*, by which the nickel is precipitated in the form of oxide; oxide of mercury produces no change in the cobalt compound. Instead of adding oxide of mercury to the cold solution of the mixed cyanides, this may be supersaturated with chlorine, and the resulting protocyanide of nickel again dissolved by caustic potassa. The chlorine has no action on the cobalt compound, whilst the nickel compound is decomposed, and all the nickel is at last precipitated as black peroxide. The operation must not be performed with heat, as otherwise sesquioxide of cobalt is precipitated with the nickel; and care must be taken that during the introduction of the chlorine the fluid is kept strongly alkaline.

In analysing ores of nickel, which contain small quantities only of cobalt, considerable excess of hydrochloric acid must be taken to precipitate the cyanides dissolved in cyanide of potassium, and the mixture must be continued in ebullition for a full hour.

γ. *Rose's Method.*—This is founded on the greater tendency in the protoxide of cobalt than in the protoxide of nickel to pass to a higher degree of oxidation. Both metals are dissolved in hydrochloric acid; the solution must contain a sufficient excess of free acid: it is then diluted with much water; if 20 or 30 grains of the oxides are operated on, about 2 pints of water are added to the solution. As cobalt possesses a much higher colouring power than nickel, not only in fluxes but also in solutions, the diluted solution is of a rose colour, even when the quantity of nickel present greatly exceeds that of the cobalt. A current of chlorine is then passed through the solution for several hours;* the fluid must be thoroughly saturated with it, and the upper part of the flask above the liquid must remain filled with the gas after the current has ceased. Carbonate of barium in excess is then added, and the whole allowed to stand for 12 or 18 hours, and frequently agitated; the precipitated peroxide of cobalt, and the excess of carbonate of barium, are well washed with cold water, and dissolved in hot hydrochloric acid; after the separation of the barium by sulphuric acid, the cobalt is precipitated by hydrate of potassa, and, after being washed and dried, is reduced by hydrogen gas, in the manner shown in Fig. 16. The fluid filtered from the oxide of cobalt is of a pure green colour; it is free from any trace of cobalt. After the removal of the barium by means of sulphuric acid, the oxide of nickel is precipitated by caustic potassa. To ensure accurate results, it is indispensably necessary to wait a considerable time, at least 12, or even better 18 hours, after the addition of the carbonate of barium, as the oxide of cobalt is precipitated very slowly.

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* Mr. Henry recommends a solution of *bromine*, which is to be added till the solution smells strongly of it; he found this to answer equally well with chlorine, and the process is rendered less tedious and unpleasant.

δ. *Another Method.*—The two oxides are covered with hydrocyanic acid, and then potassa added till a portion remains undissolved. The solution is kept boiling for a quarter of an hour, moist hydrated oxide of mercury is then added till a portion remains undissolved; a green precipitate occurs containing all the nickel, with the excess of oxide of mercury. By ignition, pure oxide of nickel remains. Acetic acid is added to the filtrate to aid reaction; it is then precipitated with blue vitriol. The blue precipitate contains all the cobalt; this is dried, ignited, redissolved in hydrochloric acid, the copper, precipitated by sulphuretted hydrogen, and then from the filtrate, the cobalt by potassa. The method depends upon the fact that *nickelo*-cyanide of potassium is decomposed by oxide of mercury, while *cobalto*-cyanide of potassium experiences no change.

(b.) *From Oxide of Zinc.*—The above method may, according to Rose, be employed for the separation of these two oxides, and also for that of other oxides from oxide of cobalt, which are strongly basic, and which are not converted into superoxides: oxide of zinc may likewise be separated from oxide of cobalt by Liebig's process with cyanide of potassium, cobalticyanide of zinc is gradually dissolved in boiling hydrochloric acid, and a clear solution is obtained: on the addition of caustic potassa and boiling, both the cobalt and the zinc are retained in solution, the former as cobalticyanide of potassium, and the latter as oxide, and from the solution zinc is precipitated by sulphuretted hydrogen) Brunner): the methods of Berzelius and Ullgren, for the separation of oxide of nickel from oxide of zinc, may likewise be employed for the separation of oxide of cobalt.

(c.) *From Oxide of Chromium.*—This is effected in the same manner as the separation of oxide of nickel from oxide of chromium.

COCHINEAL.—Cochineal is a small insect, which, as met with in commerce, has the appearance of small berries or seeds, of a dark brown or purple colour, shrivelled, and marked with little transversal furrows or wrinkles. Sometimes cochineal is superficially white, in which case it is known as *silver* cochineal, the other being called black cochineal.

Dr. Bancroft says that that cochineal is best which is large, plump, dry, and of a *silver white* colour on the surface; but this appearance is sometimes artificially given by moistening the genuine cochineal with gum-water, and then shaking it about in a bag or box containing pulverized sulphate of barium, by which the appearance of silver cochineal is at once imparted, the weight of this expensive article being thus increased to the extent of 10 or 12 per cent. with worthless heavy spar, which is then sold at the price of cochineal.

Pulverized *salt* and *carbonate of lead*, *Venice talc* and *steatite*, are used in the same manner to imitate silver cochineal.

All these falsifications may be detected by macerating the cochineal in water; the pulverized substances become loose, and may then be easily separated by decanting the turbid liquor and allowing to settle.

In order, however, to determine the tinctorial power of cochineal, the operator should take 20 grains of the sample of cochineal under examination, and also 20 grains of a sample of cochineal known to be genuine, and both should be boiled separately in a quart of water for the same space of time; each decoction is thrown upon a separate filter, and the liquors are poured into two glass measures capable of holding a quart; water is then added to each so as to make up the quart. An equal quantity of each of these liquors being now poured into the tubes of the colorimeter (see *Indigo*), the difference of colour may be ascertained and estimated from the proportion of water which must be added to the deeper solution to bring it to the same hue.

Or else, an equal portion of each of the two decoctions may be poured into two graduated tubes, and then an aqueous solution of chlorine is added until the liquor becomes yellow. The difference in the quantity of the chlorine solution employed to decolorise each liquor indicates the difference in the quality of the cochineal.

COCOA. *See* CHOCOLATE.

COFFEE.—The principal species of coffee are the Mocha or Turkey coffee, Jamaica, St. Domingo, Cuba and Porto Rico, Berbice, Demerara, Bourbon, Martinico, and Hayti. All species of coffee improve by keeping. Coffee is in the best condition when two or three years old.

The physical characteristics of coffee are the following:—The beans or berries should be of middle size, soft and rounded, of a greenish colour, free from impurities; and they should not have the slighest odour of mouldiness or any other odour, for the berries of coffee absorb most readily the effluvia from other bodies, and thus acquire an unpleasant flavour. Many cargoes of coffee have been spoiled from having been shipped with or even put into vessels which had previously been freighted with sugar. A few bags of pepper are sufficient to spoil a whole shipload of coffee.

Coffee, even that of the very best quality and in the best condition, may be impaired by improper roasting, which operation is one of some nicety, and seldom well performed. If roasted too little, the aroma of the coffee will not be fully developed, and the best coffee may then yield a vapid or effete infusion, of a *green* flavour; if roasted too much, the aroma of the coffee is dissipated, and the infusion will have a flat, bitter taste.

Coffee, after being roasted to the proper degree, should be emptied whilst hot in wooden boxes, furnished with sound and well-fitting covers; and it should be kept therein until cold, and not emptied in an open hurdle, to which a see-saw motion is given in order to cool it rapidly, as done in England. If roasted in small quantities, it may be emptied in a sheet of brown paper, and the whole wrapped up in a blanket of flannel until cold, the same sheet of brown paper being kept for that purpose.

Roasted coffee should be preserved in well-closed and perfectly dry vessels. The berries, when properly roasted, are of a full and rich brown colour, bright and oily superficially.

Coffee in grains—that is, unground—may be of inferior quality, or it may have been spoiled by contact with other substances or damaged by sea-water; but as the berry itself cannot be adulterated, damaged coffee can be directly detected, merely by smelling or chewing a few of the beans. But when ground, the case is different, and coffee may then be, and in fact *is*, adulterated to an enormous extent, by an admixture of pulverised plants or roots, previously roasted, such as *succory* or *chicory root* (Cichorium intybus of LINNÆUS), *beet-root, carrot, parsnip, madder-root, roasted beans, peas, corn*, &c. Ground coffee offers, in fact, such a temptation to fraudulent admixture, that no one should buy ground coffee except from dealers of first respectability; and even then it is much better *for the consumer* to purchase a coffee-mill, and to have his coffee ground at home. The expenditure of a few shillings will thus shelter him from all chance of fraud, and secure to him an infusion of coffee of an improved flavour, since ground coffee, even when genuine, gradually loses its aroma by keeping.

Of all the adulterations of ground coffee, that with chicory is the most prevalent. Whether the admixture of chicory with coffee, in the proportions of one or two ounces of chicory to the pound of coffee, gives *body* and *depth* of colour, is a point which cannot be disputed; it *does* give *body* and *depth* of colour, but this is a quality of a questionable nature, and one which, certainly, no exercised palate will relish. At any rate, when it is considered that the chicory itself may be purchased separately, and at a much lower price, of course, than coffee, we would advise the consumer to buy his coffee *unground*, and to add thereto whatever proportion of chicory may suit his taste.

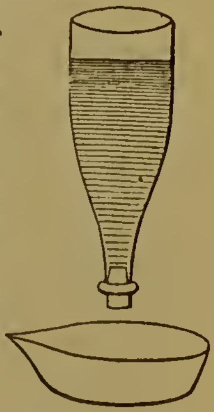
With respect to the medicinal properties of chicory, which are said to be such as to *improve* those of the coffee, and to modify its stimulating action; if it does so, it cannot be otherwise than by dilution; and those who, on that account, consider the addition not only as unobjectionable but as proper, should on the same ground allow the grocer to mix hay, or straw, or bran with his tea, with a sprinkling of extract of logwood, and the publican to add water to his beer and spirits, the whole out of pure regard to the health of the customer, and merely to correct or modify the stimulating action of these goods. Chicory has no other virtue than that of imparting a brown colour to the water in which it is boiled or infused, of giving at the same time to the liquid a flat, sweetish, bitter taste, and of *being much less expensive than coffee.* Water, in reference to beer and spirits, possesses the last quality in an eminent degree, and if used by the publican to the same extent as the chicory by the grocer, there would be no drunkards.

However this may be, the adulteration of coffee by chicory may be detected in the following manner:—

As the roots of chicory, after having been kiln-dried, roasted, and ground, resemble ground coffee so closely as to defy detection when mixed with it, it becomes altogether impossible to detect its presence by the eye alone; but if a little of the suspected coffee be first moistened, and then rolled between the fingers, it will, if in any quantity, form a little pellet or ball; whilst pure coffee, treated in the same manner, cannot be agglomerated, and remains in powder.

The presence of chicory may also be detected by throwing a portion of the suspected coffee into a glass of water, without stirring; the coffee remains for a while floating on the surface, but the ground chicory absorbs the water immediately, and falls to the bottom of the vessel, imparting a yellowish or brownish-yellow colour to the liquour. If the coffee under examination, instead of being thrown into a tumbler, is put into an inverted bottle from which the bottom has been removed, or into a funnel, the chicory, which falls down first, may be at once separated by adroitly removing the cork and collecting the chicory in any convenient vessel placed underneath; after which it may be easily identified by its taste and pastiness.

FIG. 17.



When, instead of chicory, roasted corn, peas, or beans are employed, the operator may detect the fraud by first making an infusion of the suspected coffee, decolorising it as much as possible by means of animal charcoal, and testing the *cold* liquor with an aqueous or an alcoholic solution of iodine, which in that case will produce the characteristic blue colour indicative of the presence of starch.

Not only is coffee adulterated in the manner described, but the adulterating substance itself is often sophisticated. Thus ground chicory is often mixed with *torrefied ground rice* and *corn, roasted biscuit* or *bread,* which are cheaper than chicory. The presence of these substances may be detected in chicory, as in coffee, by means of a solution of iodine; and also because, when thrown into an inverted bottle or funnel, as above described, the chicory, absorbing water more rapidly, falls at the bottom first, and may be separated, as mentioned before.

Chicory powder has been adulterated also with *brickdust, ochre,* and other earthy matters, the presence and amount of which, however, may be most readily determined by incinerating a given weight of the suspected article. 100 grains of pure chicory yield from 4 to 5 grains of fixed residue; the excess indicates the fraud.

On the Continent, the material chiefly used to adulterate both *chicory* and *coffee* is coffee-grounds; this may be detected by first drying the suspected chicory in a water-bath, and throwing a pinch of it, when dry, in water, as above directed; the chicory absorbs the water and sinks to the bottom of the vessel, whilst the *coffee-grounds* remain on the surface. When, however, coffee is adulterated with coffee-grounds, there seems to be no other way of detecting it but by the strength of the infusion, which in that case, of course, is less in proportion to the extent of the fraud.

But the best guarantee of the genuineness of coffee is in the berry, which cannot be adulterated, and which, if damaged, may be immediately recognized as being so, by smelling it and chewing a few grains. To the consumer, we would therefore say, as a general rule, 'Never buy ground coffee, if you can help it.'

Coffee is also met with in commerce as a manufactured article, in the state of essence, or rather of extract of coffee. That preparation, provided it be genuine, is peculiarly adapted to the use of travellers, who are thus enabled to procure a cup of very good coffee without trouble and apparatus.

COLOGNE YELLOW. *See* CHROMATE OF LEAD.

COPAIBA (Balsam of Copaiba).—Copaiba is a liquid resin, improperly called balsam of copaiba, which exudes principally from the *Copaïfera officinalis, Copaïfera bijuga.* Its composition is stated by Gerber and Stobze, as follows:—

Volatile oil . . .	32·0 to 47·00
Copaivic acid . . .	38·0 „ 52·00
Viscid resin . . .	1·65 „ 2·13

Balsam of copaiba is a liquid of an oily consistence, transparent, of a yellowish white colour, of a strong, disagreeable odour, and of a bitter, acrid, nauseous flavour. It thickens by exposure, and becomes more yellow; its specific gravity is 0·95, and it is perfectly soluble in rectified alcohol. The balsam of copaiba which comes from Brazil is considered the best; that from the West India Islands is less limpid than the other.

Formerly, balsam of copaiba was frequently adulterated with fixed oils; but as it is entirely soluble in rectified alcohol, the fraud can at once be detected by treating the suspected balsam with that menstruum which will leave the oil undissolved. This adulteration, however, is seldom resorted to now, and instead of the ordinary fixed oils, castor-oil, which is also soluble in alcohol, is more ordinarily employed for the purpose. This sophistication may be detected in various ways.

Mr. Adder's process consists in mixing the balsam with a solution of caustic soda, and agitating the whole violently. The liquor becomes milky at first, but if it be left at rest for a few hours, the balsam, if pure, gradually separates without alteration, and finally floats upon the alkaline solution, which has become transparent; but if the balsam contains castor-oil, a homogeneous soapy mass is formed, of a thick or even solid nature.

Mr. Henry's process consists in boiling the suspected balsam—for example, one drachm—in about a pint of water, in an open vessel. After boiling it for four or five hours, the balsam, if pure, will have been converted into a dry, brittle resin, with a vitreous fracture; but if it contains castor-oil, it will be left in the state of a more or less plastic mass proportionate to the quantity of castor-oil with which it may have been mixed.

A simpler method of obtaining the same result consists in pouring a drop of the balsam upon paper, and carefully evaporating it over a lamp. If a transparent and hard spot is left on the paper, the balsam is pure; in the contrary case the film of resin left on the paper will be soft, and an oily stain will be observed all around it, which is due to the absorption of the oil by the paper.

Another process consists in putting into a watch-glass three drops of the balsam under examination, and then adding one drop of concentrated sulphuric acid by the side of it. At the point of contact the mass becomes yellowish, and of a saffron colour all through, on stirring it with a glass tube. But if the balsam contains any castor-oil, it turns yellow at first, and soon becomes decolorized, and has the appearance of white honey. In either case the mass is ultimately charred by a prolonged contact.

Mr. Planche's process consists in mixing three parts (by measure) of the balsam with one part of dilute ammonia of sp. gr. 0·965, or weaker still; the mixture should be made in a glass tube closed at one end and well corked. The whole is then shaken, and if the copaiba be pure the mixture becomes transparent in the course of a few minutes; but if it contain any castor-oil, it forms a liniment the opacity of which is in proportion to the quantity of castor-oil present. To ensure success the temperature should not be above 70° Fahr. The presence of one-twentieth part of castor-oil may be detected by this process.

M. Blondeau's process consists in triturating one part of the balsam with four parts of carbonate of magnesium well pulverized; the mixture is then left at rest, and in the course of a few hours it becomes transparent, but thick, like a mucilage of gum arabic; but if castor-oil is present the mixture remains turbid. The magnesia may be dissolved with effervescence by an acid, and the balsam will then remain transparent if pure, but in the contrary case it is opaque.

Balsam of copaiba has been sometimes adulterated with Venice turpentine; when this is the case the balsam is thicker than when genuine, and when heated upon a hot iron the odour of turpentine is immediately rendered perceptible. When balsam of copaiba contains turpentine, it adheres to the sides of the bottle in which it is contained, which is not the case with the pure article.

COPAL.—Copal is a resin which exudes spontaneously from several large trees in America, East India, and on the coast of Guinea. The best copal is generally in lumps of moderate size, colourless, or slightly yellowish, rather dull externally, but clear internally; sometimes also it is yellow or brownish, and mixed with insects and other impurities.

The specific gravity of copal varies from 1·045 to 1·139. It is hard, inodorous, tasteless, and has a conchoidal fracture.

Gum anime is often sold under the name of copal, or copal is often mixed with lumps of gum anime, or of gum dammar, both of which it somewhat resembles. The two latter resins, however, may be distinguished from copal by careful observation. Both resin anime and dammar soften in the mouth, but genuine copal remains perfectly hard.

The best way of detecting the admixture of resin dammar, or of resin anime, with copal, consists in treating a given weight of the resin under examination with highly rectified alcohol, which dissolves both the dammar and the anime, but leaves the copal in the state of a viscid, swollen, and somewhat elastic mass.

Copal has sometimes been mixed with pieces of insoluble gum. When the lumps are sufficiently large, the fraud can hardly fail being immediately detected, the external appearance of the pieces of gum being most obviously different. But when the whole is broken in small fragments, the admixture cannot be so easily detected by its physical characters. Resin copal, however, being completely soluble in ether, whilst gum is altogether insoluble in that menstruum, the two substances may thus be most readily separated.

COPPER (Analysis of Copper Ores).—(a.) *Oxygenated ores*, comprising *oxide, suboxide, malachite*, and *phosphate of copper* (MOHR). According to the richness of the ore to be assayed, from 75 to 150 grains of the mineral reduced to an impalpable powder are warmed with weak sulphuric and nitric acids; the mixture is boiled, evaporated to dryness, and then calcined until it ceases to disengage vapour. The copper becomes transformed into sulphate, not decomposable by moderate heat, and very soluble in sulphuric acid. On the contrary, iron is converted into slightly soluble ferric subsulphate, and lead into insoluble sulphate. With *tin* and *antimony*, nitric acid forms oxides which resist the action of solvents. When the capsule is cool, distilled water is added and the solution boiled. It is then filtered; the filtrate contains all the copper, and small quantities of ferric sulphate. On treating this solution with *zinc*, the ferric salt is reduced, and the copper precipitated by boiling, in the metallic state. To make sure of the complete precipitation of the metal, it suffices to add a little solution of sulphuretted hydrogen to a drop of the supernatant liquid. To free the copper from excess of zinc, the powder is treated with hydrochloric acid, until it ceases to disengage bubbles of hydrogen gas. The metal freed from zinc is washed with hot distilled water; the action of the air must be avoided when the solution is acid, because a portion of copper would dissolve; but it is easy to avoid this inconvenience by effecting the washing promptly. The reduced copper is dried in the water-oven till it ceases to lose weight. The presence in the ore of *zinc, manganese, iron, cobalt*, and *nickel*, does not affect the precision of the analysis, neither of these metals being precipitated by zinc.

(b.) *Sulphuretted Ores.*—The treatment by sulphuric and nitric acid must be several times repeated, drying and calcining the metal between each treatment with acid. This method, the author thinks, has the advantage of being applicable to all ores, whatever their composition, and of not necessitating a preliminary qualitative analysis. In the second place, the copper is separated from metals (*lead*, *tin*, and *antimony*), from which it is freed with difficulty by ordinary methods, whilst four metals (*zinc*, *iron*, *cobalt*, *nickel*) do not influence the exactness of the estimation, and may be disregarded.

Lovel's Method of determining Copper.—This is a modification of the method proposed by Fuch for the quantitative estimation of iron (*see* Iron). The cuprous solution is introduced into a flask that can be accurately closed with a glass stopper; ammonia is added till the liquid assumes a transparent blue colour, and the flask is then filled with water, from which all atmospheric air has been expelled by boiling; a clean and accurately weighed slip of copper is introduced into the bottle, which is immediately closed; when the liquor has become perfectly colourless, the slip is removed, washed, dried and weighed; the diminution in weight which it has undergone indicates the amount of copper originally present in the solution. The result which, when properly conducted, is very accurate, depends on the abstraction of one equivalent of copper from the slip by every equivalent of oxide of copper in the solution to form an equivalent of suboxide of copper, which forms with ammonia a colourless solution. It requires a considerable time to complete the process, which is obviously altogether inapplicable in the presence of foreign metals, which are capable of being precipitated by copper.

Cassaseca's Method.—This consists in dissolving the copper compound in an acid, adding an excess of ammonia to the solution, and comparing the tint furnished by this solution, with that which a known weight of pure copper yields likewise in the state of ammoniuret.

Volumetric Methods of estimating Copper:—

(a.) *Pelouze's Method* ('Comptes Rendus,' Feb. 12, 1816).—This mode of analysis was suggested to the author by the accuracy and rapidity with which alloys of silver are analyzed by the process discovered by M. Gay-Lussac. He succeeded in effecting his object in several different ways, all based principally on the phenomena of precipitation, and simultaneous decoloration. The following was the mode of proceeding which he finally adopted:—A certain quantity of very pure copper is dissolved in nitric acid, the solution is diluted with water, and excess of ammonia added; a deep blue solution is obtained. On the other hand, some sulphide of sodium is dissolved in water, and poured into a tube graduated and divided into tenths of a cubic centimètre; the ammoniacal solution is heated to boiling, and the solution of the sulphide gradually added. If we suppose that it required 31 cubic centimètres to decolorize 1 gramme of copper, we have a standard solution of known strength. To apply this to the analysis of copper alloys, a certain known weight is dissolved in aqua regia, the solution is supersaturated with ammonia, heated to boiling, and the standard solution of the sulphide added until it is decolorized, taking care to add from time to time a little dilute ammonia to replace that which is evaporated. The decrease in the depths of the blue tint points out that the end of the experiment is more or less near, and when it is requisite to add the last portions of the sulphide in drops. When the operation is supposed to be finished, the number of divisions employed for the decoloration is read off, and compared with the number required to decolorize an equal weight of pure copper. It must be remarked that the ammoniacal liquor from which the copper has been precipitated does not long remain colourless, but gradually becomes blue in consequence of the sulphide of copper becoming partially converted into sulphate by the absorption of oxygen. This mode of operating is not, according to the author, liable to an error amounting to more than $\frac{5}{1000}$ or $\frac{6}{1000}$, though still greater accuracy is obtained by completing the decoloration of the blue liquid with a very weak solution of sulphide, precisely in the manner recommended by GAY-LUSSAC in his 'Analysis of Silver Alloys by Standard Solutions of Common Salt.' Neither *tin, zinc, cadmium, lead, antimony, iron, arsenic,* nor *bismuth,* in any way interfere with the success of this process, not being in the least affected by the sulphide of sodium while a trace of copper remains to be precipitated; indeed the author found that when the sulphides of zinc, cadmium, tin, lead, bismuth, and antimony are placed in contact with ammoniacal solution of sulphate of copper, they decolorize it, some in the cold, others with the assistance of heat, which proves very elegantly that these sulphides cannot exist, except perhaps for an instant, in a solution of copper. Their formation subsequently to the decoloration has no influence on the result of the analysis, as the termination of this is judged of by the decoloration of the liquid, without paying the least attention to the precipitates which subsequently form; or, if any attention *is* paid, it is only with a view to obtain some knowledge of the nature of the metals which accompany the copper. Thus, if any alloy consists of copper, lead, tin, and zinc, the presence of *zinc* is readily detected by the white precipitate which succeeds the black precipitate of sulphide of copper the lead and tin being precipitated at the outset by ammonia. *Cadmium*, like zinc, is precipitated immediately after the copper. The very moment the liquid is observed to be decolorized, a beautiful pure yellow precipitate of sulphide of cadmium is formed, if the addition of sulphide be continued. If the alloy contain *silver*, that metal is previously precipitated from the nitric solution by hydrochloric acid. In this method of estimating copper, an important property of ammonia, besides that of heightening the colour, is that it prevents the salts of copper being precipitated by *sulphites* and *hyposulphites*, without which it would probably have been impossible to estimate the copper by means of solutions of the alkaline sulphides, since these salts almost always occur in the alkaline sulphide, and are moreover produced from them by contact with the air. A solution of sulphide of sodium becomes weaker by contact with the air, but the alteration is very slow, nor is it necessary to change the liquid as long as any remains in the flask in which a quantity has been prepared. The only precaution to be taken—and it is one which applies to all standard solutions—is to determine previously to each assay the actual strength of the *sulphide* with a known weight of pure copper. PELOUZE states, in conclusion, that this method, applied to the analysis of copper ores, yields results of the greatest accuracy.

(b.) *C. Mohr's Method* (LIEBIG'S 'Annalen,' xcii. p. 97).—This is founded on the fact that salts of protoxide of copper are precipitated by metallic iron, the latter being converted into protoxide. The quantity of the protosalt of iron is determined by permanganate of potash.

The solution of the copper salt is put, with a few drops of hydrochloric acid, and about one-fourth of pure chloride of sodium, into a stoppered bottle; a quantity of soft iron wire is then introduced. The reduction immediately commences, and should be assisted by a heat of from 89° to 100° F. All the copper is separated in a metallic form in an hour or two, when no trace of copper can be detected in the solution by sulphuretted hydrogen. The following precautions must be observed—the solution must not be too acid, as in that case an excess of iron is dissolved; and the heat applied must not be too strong, as this causes the separation of a basic protosalt of iron in the form of a flocculent precipitate, which has no action upon the permanganate of potassium. When the reduction is completed, which may be known by the clearness of the fluid, a protosalt of iron has taken the place of the protosalt of copper. The fluid with the separated pulverulent copper is then diluted, and a measured quantity drawn off by a pipette and treated with permanganate of potassium. (*See* IRON.)

(c.) *Schwartz's Method* ('Annal. der Chemie und Pharm.' 84).—This is based on the fact that suboxide of copper reduces iron from the state of sesquichloride to that of protochloride.

To a solution of the compound in nitric acid, or in water contained in a porcelain basin, is added a solution of neutral tartrate of potassium, and then potassa or soda in excess; the blue fluid obtained is warmed on the water-bath with an aqueous solution of grape or milk-sugar; the action is allowed to continue until the blue fluid begins to turn brown; the precipitate, consisting of suboxide of copper, is allowed to subside, and then filtered and washed with hot water, till the washing water passes through colourless. The filter with its contents are then transferred to the porcelain basin, and *pure* sesquichloride of iron added in slight excess, together with a little hydrochloric acid; gentle heat is applied, and when the subchloride of copper which is at first formed is redissolved, the solution is filtered into a capacious flask, and the remains on the filter well washed; it is then allowed to cool to about 70°, and the amount of protochloride of iron determined by a standard solution of permanganate of potassium. Every 28 parts of iron found in the state of protochloride indicate 31·75 parts of copper.

(d.) *Fleitmann's Method* (Liebig's Annalen,' April, 1856, p. 141).—When the solution of copper is free from nitric acid, or injurious metals, such as antimony and arsenic, the copper is precipitated with pure *metallic zinc*, the excess of which metal is got rid of by digestion with pure sulphuric acid; the precipitate is washed, and dissolved in an acid solution of pure perchloride of iron. The solution of the copper takes place almost instantaneously, and furnishes double its equivalent of protoxide of iron, which is determined by permanganate of potassium; when nitric acid is present, ammonia is added in excess, and the precipitation of the copper effected in the filtered solution, by pure zinc shavings.

(e.) *Terreil's Method* ('Comptes Rendus,' Feb. 1, 1858).—The cuprous mineral is dissolved in nitric acid, which is completely driven off by concentrated sulphuric acid, the nitrates being converted into sulphates, ammonia is added in excess, and the liquid filtered; it is then boiled with sulphite of ammonium until colourless, and the excess of sulphurous acid is driven off by boiling with hydrochloric acid; the solution is then diluted with water, and treated with a standard solution of permanganate of potassium.

(f.) *By Cyanide of Potassium* (Parker and Mohr).—The substance is dissolved in an acid, and ammonia added in excess; a normal solution of cyanide of potassium is then added from a burette until the blue colour disappears; *two* equivalents of cyanogen are necessary to decolorize one of copper in ammonia. In this method **Field**, who has subjected the various processes for determining copper to a critical examination ('Chem. News,' vol. i. pp. 24, 61, 73), remarks that great caution and considerable practice are required to determine the necessary amount of cyanide, as towards the end of the process the decolorization is not very distinct, the solution assuming a delicate violet tint which fades very gradually, leaving at length the liquid destitute of colour; it is safer to leave a very slight tint, as it disappears after the lapse of twenty-four hours. If iron be present, it is better not to filter off the peroxide precipitated by ammonia, as it is exceedingly difficult to wash the copper out of it, and the estimation of the copper can be perfectly effected in the solution, in its presence. The solution of cyanide recommended by **Field** is 1,300 grains ot the salt dissolved in four pints of water, about 50 grains of the mineral being employed; with alloys of *tin* and *copper, antimony* and *copper*, and *arsenic* and *copper*, this method is available; but it cannot be applied to the analysis of alloys of *copper* and *zinc*, or of *copper* and *silver*; the presence of *nickel* and *cobalt* likewise interferes with its accuracy. **Fleck** ('Polytech. Centralblatt,' 1859; p. 1313) recommends to dissolve the copper compound in *carbonate of ammonium* instead of ammonia, and to add a drop of ferrocyanide of potassium to the blue liquor. The moment the cupro-ammoniacal compound is destroyed, the liquid becomes *red*.

With regard to the precipitation of copper by iron or zinc, **Field** remarks that though the estimation is never *perfectly* correct, traces both of zinc and iron being found with the precipitated copper, however carefully the operation is performed, nevertheless in a commercial point of view it is not far from the truth; but the precipitated copper should be washed with water at the temperature of 100° or 120°, to which 1 or 2 per cent. of hydrochloric acid has been added; if a stronger acid be used there is a danger of some of the finely precipitated copper being dissolved.

(g.) *Streng's Method.*—The oxide of copper is reduced by grape-sugar, a solution of starch and iodide of potassium added, afterwards a standard solution of bichromate of potassium.

When the whole of the subchloride of copper is converted into chloride, a permanent blue colour is produced; the chromic acid then reacting on the iodide of potassium and expelling iodine. **Field** finds this method to give accurate results, provided care be taken in the addition of the iodide of potassium. Diniodide of copper is very insoluble in hydrochloric acid, unless the latter be in excess, so that when a considerable quantity of alkaline iodide is employed, and little hydrochloric acid present, there is not much dichloride of copper in solution.

MM. Plessy and Moreau have founded a method of estimating copper on the following reaction:—

$$CuCl + Cu = Cu_2Cl.$$

The solution of protochloride is made as nearly neutral as possible by the addition of ammonia, and the liquor is then rendered green by the cautious addition of hydrochloric acid: a strip of copper is boiled in this solution until it becomes colourless; the loss of weight indicates the amount of metal in the chloride.

E. O. Brown ('Quart. Journ. Chem. Soc.,' vol. x. p. 65) dissolves the copper compound in nitric acid, adds carbonate of sodium, and afterwards acetic acid in excess. Iodide of potassium is then added, equal to at least six times the weight of the copper. A standard solution of hyposulphite of sodium is poured into the flask from a burette, until the brown colour nearly disappears. Clear starch liquid is then introduced, and a further addition of hyposulphite, until the blue colour is destroyed. The presence of peroxide of iron is fatal to this method, not only on account of the deep colour of the peracetate of iron, but more particularly because the peroxide becomes partially deoxidized by the hyposulphite, and thus interferes with the reaction.

In concluding his valuable review of the various methods of estimating copper, Field remarks that much must be left to the knowledge and experience of the operator. In a mixture of *lead*, *arsenic*, and *copper*, the cyanide of potassium process could be advantageously adopted, whilst the method by precipitation would be worthless, as all the metals would be reduced. Manganese and zinc do not, on the other hand, affect the precipitation of copper upon iron, but render the cyanide estimation valueless.

Kunsel has recently proposed the following modification of Pelouze's volumetric method for the estimation of copper:—*Sulphide of zinc* is employed for indicating the complete precipitation of the copper, that substance being instantly decomposed in a hot ammoniacal solution of copper. The solution of sulphide of sodium is of such a strength that one cubic centimètre precipitates a centigramme of copper. The sulphide of zinc is prepared by dissolving the metal in hydrochloric acid, supersaturating with ammonia, and then boiling with a little sulphide of zinc to remove the *lead*, which is always present in commercial zinc. The ammoniacal solution of zinc is filtered and decomposed with sulphide of sodium, a small quantity of zinc being allowed to remain in solution. The moist sulphide of zinc, with excess of zinc solution, is then spread evenly upon filter-paper, several layers thick; when the paper has absorbed most of the solution, the moist white layer of sulphide of zinc is ready for use.

According to Field, the most expeditious method of converting protosalts of copper into subsalts by means of alkaline sulphites, is to mix about equal quantities of sulphite and carbonate of sodium, and to make of these salts a strong cold solution. This liquid, poured into a protosalt of copper, instantly decomposes it. After a few minutes' boiling the whole is converted into suboxide, which dissolves in hydrochloric acid or ammonia without a shade of colour.

Detection and Estimation of Small Quantities of Antimony, Arsenic, Bismuth, and Lead in metallic Copper :—

Analysis of Commercial Copper. (Abel and Field, 'Quart. Journ. Chem. Soc.' January 1862.)

(a.) *Determination of Antimony and Arsenic.*—Two hundred grains of the metal are dissolved in nitric acid, a small quantity of solution of nitrate of lead is added, equal to about ten grains of the salt, and subsequently an excess of ammonia and carbonate of ammonium. A precipitate is formed which may consist of oxide and carbonate of lead, *arsenate* and *antimoniate of lead*, and oxide of bismuth, the whole of the copper remaining in solution. The precipitate is separated by filtration, thoroughly washed, and digested in a strong solution of oxalic acid, whereby the *antimony* and *arsenic* are dissolved. To the filtered liquid sulphide of ammonium is added, or what is preferable, it is rendered alkaline by ammonia, and hydrosulphuric acid passed through to saturation. Traces of sulphide of copper generally impart a greenish tinge to the liquid, and are deposited after some time, as it is nearly impossible to wash away the last traces of that metal from the nitrate of lead precipitate. This sulphide is filtered off, and a slight excess of hydrochloric acid is added to the filtrate, which is diluted to about eight ounces. If any large amount of either antimony or arsenic be present, there will be an immediate precipitate. If smaller quantities exist (one or two-hundreths of a grain), the flask should be placed on the sand-bath for a few hours and the temperature maintained at from 140° to 200° F., when the metals, if present, will make their appearance as sulphides. If the precipitate be orange or orange-red, the presence of antimony is certain; but if a pure canary-yellow, its absence may be presumed. The precipitated sulphides are oxidized by means of concentrated nitro-hydrochloric acid, the clear solution is mixed with chloride of ammonium and excess of ammonia, and the arsenic is separated as ammonio-magnesian arsenate. The filtrate from this is slightly acidified with dilute hydrochloric acid, and the antimony is precipitated by hydrochloric acid, and ultimately determined as antimoniate of teroxide of antimony. Should the presence of antimony and arsenic have been previously ascertained, it is of course unnecessary, in the quantitative process, to precipitate them both as sulphides from their solution in oxalic acid, as the arsenic may be at once precipitated by the addition of sulphate of magnesium and excess of ammonia, and the antimony determined in the filtrate.

(b.) *Determination of Lead and Bismuth.*—The nitric acid solution of about 200 grains of the copper is mixed with a small quantity of solution of phosphate of sodium; ammonia in excess is then added, and the resulting precipitate is collected and purified from copper, by washing with ammoniacal water. The precipitate is afterwards dissolved in hydrochloric acid, its solution is rendered alkaline with ammonia, and submitted to a current of sulphuretted hydrogen. The precipitated sulphides of lead and bismuth are thoroughly washed and dissolved in dilute nitric acid. The solution is nearly neutralized with ammonia, and then digested with a little hydrated oxide, or basic nitrate of copper, which precipitates the oxide of bismuth, while the lead remains in solution. The precipitate is thoroughly washed, dissolved in dilute nitric acid, and the bismuth separated from the copper by the addition of excess of ammonia. The oxide of bismuth thus obtained is purified by washing, and its weight determined in the usual manner. The solution containing the nitrates of lead and copper is mixed with solution of carbonate of sodium; excess of acetic acid and a small quantity of bichromate of potassium are added, and the chromate of lead is collected. Should the copper contain iron, that metal would be obtained as oxide together with the bismuth. When this is the case, which may readily be known by the brownish tinge imparted to the oxide of bismuth, they must be separated.

An extremely delicate method of testing copper for *bismuth* is the following, founded upon a curious reaction exhibited by iodide of potassium in the joint presence of lead and bismuth, first noticed by Field. About 100 grains of the copper to be examined are dissolved in nitric acid, a solution of nitrate of lead equal to about five grains of the salt is added, and subsequently ammonia and carbonate of ammonium. The precipitate is washed with ammoniacal water to free it from copper, and dissolved in warm acetic acid. Considerable excess of iodide of potassium is introduced, and the liquid is warmed until the precipitate disappears. On cooling, crystalline scales make their appearance, which by their colour indicate the presence or absence of bismuth. If that metal be absent, the scales are brilliant gold-colour, but if it be present, or even the slightest trace, they assume a dark orange or crimson tint, varying in intensity of colour according to the amount of bismuth present. If it be desired to test the copper for arsenic, the nitrate of lead precipitate is digested with acetic acid. The oxalates of lead and bismuth are insoluble in acetic acid, but it dissolves the arsenic.

Assay of Copper Pyrites (PEARSON).—Place a weighed quantity of the powdered mineral together with some chlorate of potassium in a porcelain dish (5 grammes of a variety of pyrites containing about 18 per cent. of copper are found to be enough for one analaysis, and a quantity of chlorate of potassium equal to a small tea-spoonful was added to the ore). Invert a small glass funnel with bent stem in the dish above the pyrites, and pour upon the latter rather more strong ordinary nitric acid than would be sufficient to completely cover the powder. Place the dish upon a water-bath, and from time to time throw into it small quantities of chlorate of potassium. The doses of the chlorate must be repeated at frequent intervals, until free sulphur can no longer be seen in the dish. If need be, add nitric acid also from time to time to replace that lost by evaporation.

As a general rule it is safer and more convenient to heat the mixture on a water-bath than upon sand, though the oxidation of sulphur can be effected more easily and quickly when the mixture of nitric acid and chlorate is heated to actual boiling than at the temperature attainable by means of a water-bath. When the last particles of sulphur have disappeared, remove the inverted funnel from the dish, rinse it with water, and collect the rinsings in a beaker by themselves. Allow the liquor in the evaporating dish to become cold, pour upon it a quantity of ordinary strong hydrochloric acid rather larger than the quantity of nitric acid taken at first, evaporate the mixed solution to dryness, and heat the dry residue to render silica insoluble in case any silica be present.

Pour water upon the cold residue, and without filtering the liquor with the contents of the dish into the beaker which contains the rinsings of the funnel. Heat the liquid in the beaker nearly to boiling; add to it about 25 c.c. of a strong aqueous solution of protosulphate of iron slightly acidulated with sulphuric acid, and keep the mixture at a temperature near boiling during four or five minutes, in order to destroy the small quantity of nitric acid which may have escaped decomposition in spite of the evaporation with hydrochloric acid.

The protosulphate of iron seldom or never acts instantaneously, but the reducing proceeds rapidly and perfectly satisfactorily when once begun.

When enough of the iron salt has been added, filter the mixed solution into a wide beaker, precipitate the copper in a metallic state upon a sheet of iron in the usual way, and ignite the copper in a porcelain crucible in a current of hydrogen before weighing it.

[For an elaborate article on the MANSFELD processes for estimating copper in ores, and the assay processes of STEINBECK and LUCKOW, see CROOKES's 'Select Methods in Chemical Analyses,' pp. 187 *et seq.*]

COPPER SULPHATE (Copperas Blue, Blue Vitriol, Roman Vitriol).—Sulphate of copper is met with in commerce in four- or eight-sided prismatic crystals of a fine blue colour, slightly efflorescent, inodorous, and having a styptic, metallic, disagreeable taste. The specific gravity is 2·19. The crystals are soluble in 4 parts of cold, and 2 parts of boiling water; the solution reddens litmus-paper. The crystals are completely insoluble in alcohol. Exposed to a dry atmosphere, they effloresce, lose 2 equivalents of water, and become opaque; at 212° Fahr. they retain only 1 equivalent of water, and at a temperature of about 292° Fahr. they become converted into an almost white powder, which is an anhydrous sulphate of copper, but which becomes blue again by pouring water upon it. Ignition decomposes sulphate of copper completely, and converts it into protoxide of copper.

The sulphate of copper of commerce is often contaminated, sometimes to a large extent, with sulphate of iron, of zinc, and of magnesium.

In order to detect the presence of iron in sulphate of copper, dissolve the crystals under examination in water, boil with some nitric acid, and then add to the solution an excess of ammonia. The ammonia at first precipitates both the iron and the copper; but the latter soon redissolves in the excess of ammonia, whilst the peroxide of iron is left in insoluble reddish-brown flakes, which may be collected on a filter.

Supposing, however, that the sulphate of copper under examination contains at the same time sulphate of iron, of zinc, and of magnesium, the best way of detecting the presence, and determining the amount of these impurities, is perhaps as follows:—

Dissolve a weighed quantity of the salt under examination in water, and acidify the solution somewhat strongly with hydrochloric acid; a current of sulphuretted hydrogen is then slowly passed through the acid solution until it smells strongly of the gas; a black precipitate is produced, which is sulphide of copper, and which should be rapidly collected on a filter, and washed without interruption with water containing some sulphuretted hydrogen. The sulphide of copper obtained is then dried, so that it may be easily detached from the filter, and it is transferred to a glass beaker. As the filter still retains small particles of the sulphide of copper, it should be burnt separately on the cover of a platinum crucible, and the ashes being added to the sulphide of copper in the glass beaker, the whole is treated by nitric acid, or aqua regia, until the sulphur, which separates, has acquired a pure lemon-yellow colour. The solution is then filtered, and the protoxide of copper is precipitated by means of a solution of caustic potash; the whole is moderately boiled, in order to agglomerate the oxide of copper, which may then be collected on a filter, washed with hot water, dried, ignited in a platinum crucible, which should be kept covered, and, after cooling, it is weighed. 40 grains of oxide of copper represent 80 grains of anhydrous sulphate of copper, or 125 grains of the ordinary crystals.

The liquor filtered from the sulphide of copper, produced by sulphuretted hydrogen, should now be heated until all odour of the gas has disappeared; nitric acid is then poured into it, and the whole is boiled, in order to peroxide the iron; the acid liquor should now be neutralised with ammonia, and precipitated by succinate of ammonium. The liquor filtered from the persuccinate of iron produced should then be treated by hydrosulphuret of ammonia, which, if zinc is present, will produce a white precipitate of sulphide of zinc, which may be converted into oxide of zinc, exactly as described in the article on *Zinc.* The liquor which was filtered from the sulphide of zinc may finally be supersaturated with hydrochloric acid, in order to decompose the hydrosulphuret of ammonia, and the magnesia which is in solution in that liquor is precipitated in the state of bibasic phosphate of ammonium and magnesium by means of a solution of phosphate of sodium with addition of ammonia. This precipitate should be mixed with some ammonia. The precipitate should be left at rest for several hours (about twelve), because it takes a long time to settle; after which it may be collected on a filter, as above said, washed, thoroughly dried, and gradually submitted to an intense heat, in a covered platinum crucible. After cooling, it is weighed. 1 grain of pyrophosphate of magnesium contains 0·36637 grain of magnesia.

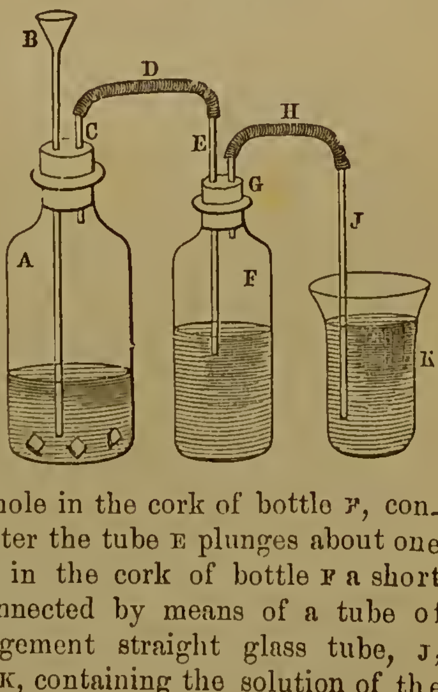
COPPER ACETATE (Sub-acetate of Copper, Verdigris, Œrugo, Verditer).—The acetate of copper of commerce is a basic salt of copper, which is met with in lumps or cakes of about twenty-five pounds weight, packed up in white leather. This article, which is extensively used by painters and dyers, and in medicine, is often adulterated to a large extent with *chalk* and with *sulphate of copper.*

The presence of *chalk* is detected by pouring hydrochloric acid upon a given weight of the verdigris previously pulverized. If chalk be present, an effervescence will take place, but if pure the verdigris will dissolve in the acid without effervescing. Some impurities will, however, be left in an insoluble state, which should be collected on a filter, washed, dried, and weighed; in the genuine articles their proportions should not exceed 5 or 6 per cent.

To the liquor filtered from the insoluble impurities, solution of chloride of barium is added; if this produces a white precipitate it is sulphate of barium, and indicates the presence of sulphuric acid. The liquor containing this precipitate must be well shaken, and the precipitate, being separated by filtering, should be washed, dried, ignited, and weighed. 117 grains of sulphate of barium = 40 grains of anhydrous sulphuric acid, and consequently 80 grains of anhydrous *sulphate of copper*, or 125 grains of this salt in crystals.

In order to determine the proportion of *carbonate of calcium*, a given weight of the verdigris, dissolved in hydrochloric acid, as above mentioned, should be treated by a current of sulphuretted hydrogen, until all the copper is precipitated in the state of sulphide of copper.

FIG. 18.



This is done in the following manner: A, Fig. 17, is a bottle containing a few lumps of protosulphide of iron, and provided with a perfectly air-tight cork, perforated with two holes, through one of which a funnel is introduced, and through the other hole a short straight glass tube, C, protrudes, which is connected by means of a tube of vulcanized caoutchouc, D, with another glass tube, E, which passes through a hole in the cork of bottle F, containing water, and into which water the tube E plunges about one inch deep; through another hole in the cork of bottle F a short straight tube of glass, G, is connected by means of a tube of caoutchouc, H, with a disengagement straight glass tube, J, which is immersed in the beaker K, containing the solution of the acetate of copper under examination. Sulphuric acid, diluted with water, being poured through the funnel B, into the bottle A, containing protosulphide of iron, a copious stream of sulphuretted hydrogen is immediately evolved. All the joints should, of course, be perfectly air-tight. The water in the bottle F serves to wash the gas.

The stream of sulphuretted hydrogen should be passed through the solution of acetate of copper until the latter smells strongly of the gas, even after shaking it well. The black precipitate of sulphide of copper thus produced is separated by filtering and washed. The filtrate is then neutralized by ammonia, and treated by oxalate of ammonium, which will precipitate the lime as oxalate of calcium. It is collected on a filter, washed, dried, and ignited in a platinum crucible. Ignition converts it into carbonate of calcium, and as such it is weighed, or, which is better, it may be converted into *sulphate of calcium* by dilute sulphuric acid and subsequent ignition. 68 grains of sulphate of calcium correspond to 50 grains of carbonate.

Pure verdigris is completely soluble, not only in hydrochloric acid, but also in ammonia, and with the help of heat also in dilute sulphuric acid.

The buyers of this article generally judge of its value by the brightness of its colour, and by its dryness; by rubbing it in the palm of the hand with a little water, it should form a smooth paste free from grittiness.

The best verdigris is made at Montpelier, in France. The English verdigris is made from the refuse of cider, and is much inferior to the French.

COTTON and LINEN.—Linen fabrics are often mixed with cotton. M. KINDT proposed, as a means of detecting these two substances from each other, a method which is grounded upon the power which concentrated sulphuric acid possesses of dissolving the cellulose of cotton more rapidly than that of flax.

The mode of proceeding is as follows:—A portion of the tissue is first boiled in water, in order to remove the stiffening; it is then dried, cut in half, weighed, and one of the halves is plunged into concentrated sulphuric acid for two minutes. The tissue, which has then become transparent, is again boiled in water, for the purpose of removing the gummy substance produced; this removal may be promoted, if needful, by friction between the fingers. The acid is ultimately eliminated by washing the tissue with a weak solution of alkali, then with pure water, after which it is dried. As in this process the threads of cotton have been dissolved, their amount may be immediately determined by the loss as compared with the portion which has not been submitted to the action of the sulphuric acid.

If the piece were left too long in the acid, the flax would likewise be attacked; but if the tissue contain no cotton, the corrosion will have been uniform, whilst in the contrary case the cotton is first attacked and converted into gum, whilst the flax remains white and opaque.

A concentrated solution of caustic potash may also be employed for the purpose, as follows:—A piece of the tissue is to be boiled for two minutes in a strong solution of caustic potash, and then dried between folds of blotting-paper. Upon unravelling it the linen threads will be found to have acquired a dark yellow tinge, whilst those of cotton have remained white, or have only become slightly tinged with yellow.

The presence of cotton in a tissue may also be detected by the microscope, the fibres of cotton having a flat and shrivelled appearance, while those of flax are round and straight.

Cotton and Wool.—To distinguish cotton from wool, boil a square inch of the tissue in a solution of caustic soda. The whole of the wool will be dissolved, while the cotton fibres are scarcely injured at all by this treatment; and if the threads have been previously counted, their relative proportions may be thus directly estimated.

Cotton from Wool and Silk.—If the tissue be whole, the presence of silk or of wool may be distinguished from cotton by means of chlorine; for if the tissue be exposed to the action of this gas the wool or silk becomes yellow, whilst the cotton remains white.

The presence of cotton may be most easily recognised and distinguished from wool and from silk by unravelling the suspected tissue, and inflaming the threads so unravelled. Wool and silk threads, when so treated, shrivel up, burn with difficulty, and with a characteristic odour, and leave a voluminous charcoal; whilst cotton threads burn rapidly, leave no charcoal, and evolve no odour.

CRUDE TARTAR. *See* BITARTRATE OF POTASSIUM.

CRYSCOLLA. *See* BORAX.

CRYSTAL. *See* GLASS.

CUBIC NITRE. *See* NITRE.

CUTCH. *See* CATECHU.

DUTCH GOLD. *See* BRASS.

DUTCH WHITE. *See* LEAD CARBONATE.

ELECTRAM. *See* GERMAN SILVER.

EPSOM SALTS. *See* SULPHATE OF MAGNESIUM.

ESSENTIAL OILS. *See* OILS.

ETHER.—Ether is the name of a compound which is produced under a great number of circumstances; but the substance popularly known by the term *Ether*, and which is used almost exclusively both for manufacturing purposes and in the laboratory, is that formed by the action of concentrated sulphuric acid upon alcohol, and is known as sulphuric ether.

Ether, when pure, is colourless and very fluid; it has a peculiar, strong, penetrating, but agreeable odour, and a burning, pungent, sweetish flavour. It should be perfectly neutral to test-paper.

The ether of commerce is generally unsophisticated, but it is nevertheless found much less pure or strong than should be. The only adulteration to which ether is liable is by an admixture of alcohol, in which it is soluble in all proportion. The presence of alcohol in ether, however, is very easily recognized by pouring a certain quantity of the suspected ether into a graduated tube, and adding a small quantity of water, which, dissolving the alcohol, produces a much more considerable diminution of volume, if the ether contain that body, then when it is pure; of course the mixture should be shaken. It should be recollected that 10 parts of water dissolve 1 of ether, and consequently that a diminution in that proportion will always take place, even with pure ether, for which an allowance must be made.

The alcohol employed in the manufacture of ether should be very pure, or well rectified; otherwise the ether will have a much less agreeable or even an unpleasant odour, due to the presence of *fusel* or other essential oil.

The specific gravity of good ether is 0·775.

The oxygen of the air slowly acidifies ether, owing to which it frequently reddens litmus-paper; such ether should be redistilled with potash or caustic magnesia. The operator, in doing this, should bear in mind that the vapour of ether is highly inflammable and *heavy*, and that it frequently happens that in falling upon *red-hot* coals, or the flame of gas, of candles, or of other ignited bodies, it may catch fire, and cause serious accidents.

Ether is principally used as a solvent in certain analytical operations, to detect and isolate bromine, and in the preparation of a great number of organic bases, &c.

Ether is sometimes used as an anæsthetic agent, but chloroform and nitrous oxide gas are now generally employed in preference.

FERROCYANIDE OF POTASSIUM (Yellow Prussiate of Potash).—The ferrocyanide of potassium of commerce is generally in large and beautiful crystals of a fine lemon yellow colour, which should be entirely soluble in alcohol.

The yellow prussiate of commerce is sometimes contaminated by sulphate of potassium, the presence of which may be detected by dissolving a portion of the salt in water, and adding thereto a solution of chloride of barium, or of nitrate of barium, which will then produce a white precipitate of sulphate of barium, insoluble in water and in acids, if sulphate of potassium be present. The precipitated sulphate of barium should be collected on a filter, washed, dried, ignited, and weighed. 116·6 grains of sulphate of barium correspond to 87·0 grains of sulphate of potassium.

This substance has become an important article of commerce, large quantities of it being consumed by calico-printers and dyers, by the manufacturers of Prussian blue, and in electro-plating.

FIXED OILS. *See* OILS.

FLOUR.—The substances principally employed for the purpose of adulterating wheat flour are *fecula*, or *potato-starch*, *bean-flour*, *Indian corn-flour*, *rye*, and *rice-flour*, which alimentary substances are objectionable only when the flour containing them, or the bread made with such flour, is sold as genuine wheat-flour or bread; but besides these so far venial additions, flour is sometimes sophisticated by *alum*, *chalk*, *bone-dust*, and *plaster*.

Detection of Potato-flour.—This admixture of this fecula is well detected by the microscope. The particles of potato-starch are irregular in shape, and of various sizes; and, moreover, upon placing a little of the suspected flour before the microscope, and moistening it with a solution of potash, the particles of wheat-flour undergo no change whatever, whilst the globules of fecula spread into thin, transparent plates.

Although the presence of fecula can be detected even when in extremely minute proportion, yet it would appear that its quantity cannot be very rigorously estimated when under 10 per cent.; but an adulteration below 10 per cent. is scarcely probable, since it would hardly, if at all, be remunerative; on the other hand, DUMAS asserts, that when fecula is added to wheat-flour, to the extent of 30 per cent., it is impossible to make bread with it. It may, therefore, be assumed that the addition of fecula to wheat-flour ranges from 10 to 25 per cent.; but, as we said before, the presence of a much more minute quantity can be detected.

One of the methods of doing this is the following, which, according to M. CHEVALLIER, can be applied with advantage, not only to flour which has been simply mixed with fecula, or which has been ground with it, but likewise to vermicelli, macaroni, &c.:—

Take of the flour under examination	300 grains.
„ Sand	300 „
„ Water	2 ounces.

Triturate the flour and the sand in a Wedgewood mortar for about five minutes, adding the water gradually, so as to form a homogeneous paste, which is then to be diluted with the remainder of the water. This being done, throw the whole on a filter, and whilst filtering prepare an aqueous solution of iodine, by pouring about two ounces of water upon about 50 grains of iodine, and shake the whole for about ten minutes; the aqueous solution is then decanted, and the undissolved iodine is kept for further use. Of the aqueous solution of iodine so prepared, pour one ounce into an equal quantity of the liquor filtered from the flour. If the flour be pure, this addition will produce a pink colour, which, however, gradually disappears more or less rapidly; whilst, if the flour contain 10 per cent. of fecula, the liquor will become of a dark purple colour, which disappears much more slowly. This experiment should be performed simultaneously with flour which is known to be pure.

If now the liquor be examined after a short time, it will be seen that the colour of the liquor obtained from the pure flour begins to disappear from the bottom of the glass upwards, and in the course of eight or ten minutes it completely disappears; whilst, if fecula be present, the decolourization begins likewise from the bottom upwards, but the purple or violet colour persists for a long time at the surface, so that the liquor forms two distinct strata, the lower of which is colourless, the upper one purple.

Another process by which the quantity of fecula added to flour may be accurately estimated is that proposed by M. Robine; it is as follows:—

Take 500 grains of the suspected flour, and mix it in a glass beaker with a glass rod, with 200 grains of cold water. The whole being mixed to a doughy consistence, the mass is then squeezed in the palm of the hand, whilst holding it in a basin half full of water, by which means the gluten is separated, and ultimately left in the hand, in a pure state, under the form of an elastic and glutinous mass, which may be weighed. The small pieces of gluten which may have escaped and have fallen in the basin, should be, of course, collected and weighed with the portions of gluten already obtained.

The water in the basin which contains the starch should now be well stirred, and poured, whilst turbid, into a conical glass (a six-ounce glass measure answers the purpose well), and the whole is then left at rest. At the end of an hour a deposit will have formed at the bottom of the glass, which must be left undisturbed. When the whole has been left at rest for two hours, the supernatant liquor is carefully syphoned out, and the whole being left again undisturbed for two hours, any water which may be observed floating above the deposit may be carefully sucked up by means of a pipette.

On examining the deposit, it will be found to be in two distinct layers; the upper one has a grey colour, and consists of a mixture of gluten, in a finely divided state, and of albumen; the lower layer, which is opaque and white, is starch.

The upper layer should be carefully removed with a teaspoon, down to the compact layer of starch, which is known, because it feels harder and stiffer; the second layer should be left undisturbed until it has become quite solid by drying. When it is in that state, it may be easily removed from the glass by pressing it gently with the finger all round until it is detached, and it may then be upset in the form of a cone, upon a lump of dry plaster. The potato-starch being heavier than that of wheat, forms the apex of the cone; its thickness, or depth, and consequently its quantity, may be estimated by solution of iodine, in the following manner:—The operator cuts from the apex of the little cone above-mentioned a slice, which he triturates only for a short time in an agate mortar (one of glass, or porcelain, or Wedgewood, will not do), and he tests that with solution of iodine. If it turn blue, it is fecula. Another slice is treated in the same manner, until the operator comes to the wheat-starch, which, in the present instance, will not be affected by the aqueous solution of iodine. This difference of behaviour of the two species of starch with iodine is due to the friction of the pestle and mortar, which is sufficient to divide or tear the envelopes of the particles of the potato-starch, which then become blue, when treated by solution of iodine. The particles of wheat-starch, on the contrary, are not disaggregated by that treatment, and being therefore protected by their envelope, are not acted upon by solution of iodine, or assume only a brown tinge.

Hot water, or heat in any way, must not be employed in that experiment, for it would burst the envelope containing the starch of the wheat, which would in that case be coloured blue also by solution of iodine, and therefore spoil the experiment. For the same reason, the cone of starch must be left to dry spontaneously, and not by applying heat; neither should trituration be continued too long. The asperities of a Wedgewood mortar would tear the globules of starch, and produce the same effect as heat; one of glass, or of glazed porcelain, would altogether fail in dividing them, and in that case potato-starch would simulate wheat-starch. The number of slices which have been coloured blue by iodine, corresponding to the graduations of the glass measure, indicate at once the relative proportion of the potato-flour.

When flour is adulterated with *maize*, or *Indian corn*-flour, or with *ground rice*, the best method of detecting it is by the microscope. The suspected flour should first be washed under a thin streamlet of water, or in a basin half filled with water, in order to separate the gluten; and a portion of the starch which deposits being examined before the microscope, or with a magnifying-glass, fragments of an angular shape and semi-transparent will be observed, if maize or rice is present. Bread made with flour containing a certain quantity of these substances feels harsh and dry; and if the proportion of Indian corn is at all considerable, the flour has a yellow appearance, it feels coarse, and has moreover a peculiar sweet and caky flavour.

When wheat-flour has been mixed with *bean-flour*, the meal has a yellowish appearance, feels soft, and has a peculiar bitter or acrid flavour of beans.

To detect the presence of *bean-flour*, Mr. Rodriguez proposed the following method, which is accurate. It consists in submitting the suspected flour to dry distillation in a stone retort, and collecting the distillate in a vessel containing water, which will be found to have acquired an alkaline reaction. If, on the contrary, the wheat-flour is pure, the water in which the distillate will have condensed will remain perfectly neutral. This alkaline reaction takes place when beans, pulse, or pea-meal has been added to wheat-flour.

Another process is the following:—

Take of the flour under examination	300 grains.
„ Sand	300 „
„ Water	2 ounces.

Triturate the flour and the sand strongly for about five minutes in a Wedgewood mortar, and add the water gradually by small portions at a time, so as to form a homogeneous paste, which should then be diluted with the remainder of the water. On filtering, it will be observed that the flour which contains bean-flour filters much more slowly, and remains milky. A portion of the filtrate should then be mixed with its own bulk of solution of iodine, prepared expressly for the experiment, exactly as was described before in speaking of potato-flour.

The liquor filtered from pure wheat-flour, being tested by the solution of iodine as above directed, assumes a deep pink colour, but that which contains bean-flour has a pink colour of a lighter hue, and is more permanent than the other.

Detection and Determination of Chalk in Flour.—A given weight of the flour—for example, 500 grains—are to be mixed with about 2,000 grains-measure of pure distilled water, and hydrochloric acid is added. If the flour contain chalk in the proportion of 1½ or 2 per cent. or more, an effervescence will be observed, owing to the disengagement of carbonic acid. The mass is then thrown on a filter, the filtrate is exactly neutralised by ammonia, and tested with oxalate of ammonium, which will then produce a precipitate of oxalate of calcium. The liquor is left at rest for a few hours, in order that the precipitate may settle well; it is then collected on a filter, washed, carefully dried, and ignited. Ignition converts it into carbonate of calcium (chalk), in which state it is weighed, or it may be converted into sulphate of calcium as directed in p. 162.

Bread made with flour containing more than 4 per cent. of chalk is spotted here and there with white marks, which are due to an agglomeration of small quantities of carbonate of calcium.

Pure flour, of course, does not effervesce by treatment with hydrochloric acid.

The following process may serve to detect sophistications with earthy or such like matters. A portion of the suspected flour—200 grains for example—is first well dried, incinerated, and then weighed. The residiuum from pure flour should not exceed from 8 to 9 per cent. If more than this, the flour may be looked upon as adulterated.

The presence of *alum* in flour is detected exactly as in bread. (See the article on *Bread.*)

The physical characteristics of wheat-flour of good quality are the following:—It has a dull white colour, somewhat inclining to yellow; it should exhibit to the eye no trace of bran, even when pressed smooth either with the hand or with a polished surface. It should have a homogeneous appearance, and not lose more than from 6 to 12 per cent. after drying it in a stove. The less it loses by drying the better it is.

FLOWERS OF BENZOIN. *See* BENZOIC ACID.

FLOWERS OF ZINC. *See* OXIDE OF ZINC.

FRANKINCENSE. *See* BENZOIN.

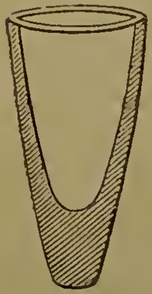
FUMING SULPHURIC ACID. *See* SULPHURIC ACID OF NORDHAUSEN.

GALENA (Sulphide of Lead).—The ore from which lead is principally obtained is *galena*, or sulphide of lead. Galena ordinarily contains silver; the whole of the precious metal passes into the lead, from which it is separated afterwards, in the large way, by Mr. PATTINSON'S process, namely, by crystallization and cupellation. The other substances most generally mixed with galena are quartz, sulphate of barium, iron, or arsenical pyrites, and blende (sulphide of zinc).

The proportions of lead and of silver contained in galena may be determined in the wet and in the dry way; but the former seldom gives accurate results, is more tedious, and if the quantity of silver in the lead obtained is excessvely minute, its estimation in the wet way cannot be at all relied upon.

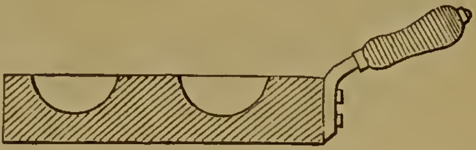
Determination of the Amount of Lead contained in Galena in the Dry Way.—For such an analysis the operator must be provided with a good air-furnace, which should be charged with coke, and lighted. When it is brought to as high a temperature as possible, a conical wrought-iron crucible should be plunged in the middle of the coke. The crucible, (Fig. 19) generally employed is 4 inches high, 2 inches wide, and very thick at the bottom, as represented in the figure in the margin. The galena must be pulverized very carefully, for otherwise it will decrepitate under the first impression of the heat. When the crucible has attained a dark red heat, 1,000 grains of the pulverized galena are introduced into it; and when the mass of the pulverized ore has attained the temperature of the crucible, and therefore before it (the galena) has entered into fusion, the operator takes a stout iron wire or rod, about the size of a quill, and about 3 feet long, flattened at one end, so as to form a little spatula, which should always be kept in a perfectly clean state, and by means of which he gently stirs the mass in the crucible in order to expose all its surfaces to the action of the air for the purpose of roasting it, taking care, however, that the spatula does not become red hot, for in that case some of the galena would permanently adhere to it, and some of the lead would be reduced; to prevent this the spatula should be withdrawn from time to time, to allow it to cool, should it become too hot. This precaution, however, is almost superfluous, since the roasting is almost completed in one minute. Even though the spatula has not become red hot, a portion of galena is always found adhering to it, but it does not hold fast, and may be easily detached by scraping it with a knife; and should a small portion be still adhering to the edge of the spatula, which is generally the case, it may be readily removed by holding the spatula in a vertical position, moving it backwards and forwards, whilst pressing strongly enough on its edge to break and detach the said portions. All these little fragments must of course be returned to the crucible, which should

FIG. 19.



then be kept covered, and the whole mass is allowed to attain a cherry-red heat, when two large spoonfuls of the flux, described afterwards, must then be thrown into the crucible, which must now be brought to a full white heat. This will take about twelve or fifteen minutes. A piece of green wood, about three-quarters of an inch in diameter, should be plunged in the crucible, its sides rubbed and scraped with it so as to detach the small particles which are adhering to them, so that these small particles may be sunk into the mass now in fusion. The fused scories should also be slightly stirred with the piece of green wood, in order to precipitate any particle of lead which they might retain. The piece of wood should be kept moist, in order to prevent the scoriæ from adhering to it. The crucible is then to be covered, and left in the fire for about two minutes longer, the fused mass being kept in full liquidity during that time. The crucible is then withdrawn from the fire by seizing it with a pair of crucible tongs, the branches of which are horizontal, and the contents thereof are poured into an ingot mould of brass, Fig. 19*, in the following mannner:—the crucible is brought with the tongs on the edge of the ingot mould, the tongs resting firmly on the said ingot mould; it is then gently tilted, and the scoriæ are carefully poured into one of the recesses of the ingot mould, until, in so doing, the operator begins to see the melted lead in the crucible. He then rakes up carefully the scoriæ which still remain in the crucible, pushing and pressing them alternately on each side until they have become sufficiently stiff by cooling to allow of the molten lead being poured separately in the other recess of the ingot mould.

FIG. 19*.



In order to be certain that the scoriæ in the first recess retain no lead, the whole mass of the scoriæ is returned into the iron crucible, which is then carefully scraped with the spatula of the stout iron wire above described, in order to collect all the particles which may be adhering to it. The operator then adds about half a spoonful more of flux, and the whole is replaced in the fire. When the mass is perfectly fused, which should be done as rapidly as possible, the crucible is again cleansed with the piece of green wood, and the whole is at once poured, scories and all, into one of the empty recesses; the molten lead percolates and collects at the bottom.

When the scoriæ contain a certain quantity of lead, they, in cooling, contract, and a portion of the metal might thus be projected and lost. In order to avoid this accident, no sooner is the fused mass poured into the ingot mould than it must be immediately turned upside down; the lead, by coming in contact with the cold mass of brass of the ingot mould, is at once solidified, and by upsetting immediately the ingot mould, it has no time to be refused by the hot scories from which it is thus cleanly separated. The little button of lead thus obtained is flattened with a hammer in order to eliminate the film of scoriæ which covers its surface, it is added to the rest of the lead obtained before, and the whole of the lead is then weighed.

The flux employed consists of three parts of red argol, two parts of nitre, one part of borax, half part of fluor spar. The whole must be well pulverized and thoroughly mixed.

When the ore of lead is refractory, a small quantity of potash (about a spoonful) should be added for each 1000 grains of ore, and the roasting may then be dispensed with.

In this experiment a very high temperature is always required, because in that case the iron crucible lasts longer, since it needs not be left so long in the fire as would otherwise be necessary; and, moreover, if the temperature was not very high, a large quantity of oxide of iron mixing with the mass would render it very infusible, and the operation would be spoiled.

In order to estimate the quantity of silver contained in the lead thus obtained, 500 grains of it are placed in a dry cupel of bone-ash, and placed in the cupelling furnace, as described in the article on *Silver*. The metallic button of pure silver left on the cupel is then detached and weighed.

Assay of Galena in the Wet Way.—Treat the pulverized mineral with concentrated nitric acid; evaporate to dryness with a small excess of sulphuric acid; treat the dry mass with water, which dissolves out all the sulphates but that of lead. *Tin*, *antimony*, *quartz*, and *sulphate of barium* would, if present, be left in the insoluble portion. Collect and weigh the insoluble portion; digest it repeatedly with acetate of ammonium (sp. gr. 1·065), wash, dry, and weigh. The difference indicates the amount of sulphide of lead. The lead may be precipitated from its solution in acetate of ammonia by sulphide of ammonium, and the sulphide of lead may be oxidized into sulphate by nitric and sulphuric acids.

Store's Method.—Weigh out 2 or 3 grammes or more of the finely-powdered mineral. Place the powder in a tall beaker, together with a smooth lump of pure metallic zinc about an inch in diameter, and a quarter of an inch thick. Pour upon the mixed mineral and metal 100 or 150 c.c. of warm hydrochloric acid, 1 part commercial acid and 4 parts water, and cover with a glass plate. Allow the action to go on for twenty minutes, stirring from time to time with a glass rod. When the liquid has become clear, throw it on a smooth filter on which a small piece of metallic zinc has been placed. Wash the lead and zinc in the beaker as quickly as possible with hot water by decantation, until the liquid from the filter ceases to give an acid reaction with litmus-paper; then transfer the lead from the beaker to a weighed porcelain crucible. In order to remove any portions of lead which adhere to the lump of zinc, the latter may be rubbed gently with a glass rod. Wash out the filter into an evaporating-dish, remove the fragment of zinc, and add the particles of lead thus collected to the contents of the crucible. Finally, dry the lead at a moderate heat in a current of ordinary coal-gas, and weigh.

If the mineral to be analyzed be contaminated with a siliceous or other insoluble gangue, the metallic lead may be dissolved in dilute nitric acid after weighing, and the insoluble impurity collected and weighed by itself. In the case of galenas which contain *silver*, *antimony*, *copper*, or other metals precipitable by zinc, the proportion of each metal must be determined by assay or analysis in the usual way, after the total weights of the precipitated metals have been taken.

GALLS (Gall Nuts).—Galls are excrescences produced by the puncture of a small insect on the shoots and leaves of plants, and trees of various kinds, for the purpose of depositing its eggs. The best galls are those found on a species of oak (*Quercus infectoria*) in Asia Minor, Syria, Persia, and other places; the best being those of Aleppo, which are tubercular and almost prickly on the surface, their size varying from that of a pea to that of a large filbert. The best are small, heavy, hard, brittle, and of a bluish colour; they are called *blue galls*.

The *green galls* which, like the blue, are galls from which the insect has not escaped, are nearly as good as the blue galls; both are about one-third more effective than the *white galls*, which are the nuts gathered after the insect has escaped by eating its way out.

White galls are of a yellowish colour, perforated, light, and much less valuable.

The only fraud to which this important article is subject consists in dyeing the white galls, so as to simulate the colour of the blue galls, pass them off as such, and consequently obtain a higher price.

This sophistication, however, may be readily detected by the most casual observation, since all white galls are perforated, and much lighter than the blue or green galls; they are also much more easily broken, and they are then found to be hollow, the inside being full of a dry white powder, instead of being hard and compact, as is the case with the genuine blue and green galls. According to Sir H. Davy, 500 parts of galls contain—of tannin 130 parts, of gallic acid 31, of mucilage 12, and of saline matter 12, the remainder consisting of woody matter. The active principles of galls are taken up by water and by alcohol.

GARANCINE (Alizarine). *See* MADDER.

GERMAN SILVER (Packfong, White Copper, Electrum, Tutenag, Albata, Maillechor, Argentan, Tombac, Amalgamated Silver).—These alloys consist of nickel, copper, and zinc, in various proportions, with sometimes a little lead and iron. See the following Table:—

	Good Maillechor Argentan	Ordinary		Electrum		Tutenag		Packfong	For Casting	Tombac
Nickel .	25	23·8	20·68	29·0	34·4	27·15	13·0	31·6	23·14	97
Zinc .	25	18·9	24·13	19·4	19·9	27·00	25·0	25·4	18·52	2
Copper.	50	59·3	55·19	51·6	45·7	45·85	57·4	40·4	55·55	,,
Iron .	,,	,,	,,	,,	,,	,,	9·0	2·6	,,	,,
Lead .	,,	,,	,,	,,	,,	,,	,,	,,	2·83	,,
Arsenic	,,	,,	,,	,,	,,	,,	,,	,,	,,	1
	100	100·0	100·00	00·0	100·0	100·00	100·0	100·0	100·00	100

The solder used for German silver consists of five parts of German silver and four parts of zinc. The alloy, when melted, is run into thin flakes, and then reduced to powder.

Under the name of *amalgamated silver plate*, forks, spoons, and other similar articles have lately been offered for sale. These utensils look certainly more beautiful than the common German silver, but instead of consisting of an alloy of pure silver, with a *new white metal*, as represented in the prospectus of the seller, and thus accounting for the high price of his wares, the alloy is nothing else than very common German silver, upon which a film of silver has been deposited by galvanic agency.

Analysis of German Silver.—Take 50 grains of the alloy and dissolve them in pure nitric acid (diluted). The solution being completed, and the excess of acid eliminated by evaporation, dilute the solution with a large proportion of water.

Observe that, whilst dissolving, the German silver, if *plated* with silver, will be unequally attacked, and the acid will dissolve the alloy more rapidly underneath, leaving the silver in a thin shell before the whole has dissolved. The operator should then examine this silver shell, and if it have a polished surface on both sides, the silver has been deposited by galvanic action; in the contrary case, the article examined has been plated in the usual way. This having been ascertained, and the whole having been dissolved, hydrochloric acid is added to the solution, in order to precipitate the silver, and the whole is moderately heated, in order to agglomerate the precipitated chloride of silver produced; it is then collected upon a filter, as small as possible, washed, dried with care, and ignited in a small porcelain crucible, the filter being burnt separately upon the cover of the crucible, with which the latter is subsequently to be closed. After fusion and cooling, the chloride of silver is weighed; 143.5 grains of chloride of silver represent 108 of silver; or, each grain of chloride of silver contains 0·7526 of silver.

The proportion of silver may also be determined by measure, that is, by means of a test solution of hydrochloric acid, of a known strength. (*See* ASSAY OF SILVER.)

The liquid filtered from the chloride of silver produced should next be treated by sulphuretted hydrogen, a stream of which should be passed through the liquor until it smells strongly of the gas. The black precipitate produced is separated by filtering, washed, and digested in strong nitric acid; sulphuric acid is then added to the solution, which will precipitate the lead, if this metal be present. Supposing this to be the case, the whole should be evaporated to dryness, and a stronger heat applied towards the end, in order to evaporate the excess of sulphuric acid employed. The dry mass is now treated by water, which will leave the sulphate of lead in an insoluble state; it is then collected on a filter, washed, dried, slightly ignited in a porcelain crucible, and weighed. 152 grains of sulphate of lead contain 104 of lead; or, each grain of sulphate of lead contains 0·73563 grains of lead.

To the liquor filtered from the sulphate of lead—or, if that metal be absent, to the nitric acid solution of the sulphide produced by sulphuretted hydrogen—potash is now added, which will precipitate the copper in the state of protoxide of copper; the whole is boiled, the precipitate oxide of copper is collected on a filter, washed with hot water, dried, ignited, and weighed immediately after cooling, the crucible being kept well closed, in order to avoid absorption of moisture. 39·75 grains of protoxide of copper contain 31·75 of copper; or, each grain of protoxide of copper contains 0·7987 of copper.

The liquor which was filtered from the precipitate produced by sulphuretted hydrogen should now be boiled, to expel the sulphuretted hydrogen; and when all odour of the gas has vanished, carbonate of sodium is poured into the liquor, and the whole is boiled for a few minutes, by which means the zinc and the nickel are thrown down. The precipitate should be collected on a filter and dissolved in acetic acid, which converts the nickel and the zinc into acetates of these metals. The solution should contain an access of acetic acid. A current of sulphuretted hydrogen being now passed through the solution, the zinc will be precipitated in the state of sulphide of zinc, whilst the nickel will remain in solution. The precipitated sulphide of zinc is then separated by filtering, washed, and redissolved in hydrochloric acid, from which it is finally reprecipitated as carbonate of zinc, by a solution of carbonate of sodium. This precipitate is then collected on a filter, washed, dried, and ignited. Ignition converts it into oxide of zinc, in which state it is weighed. 40·75 grains of oxide of zinc contain 32·75 of zinc, or one grain of oxide of zinc contains 0·8027 of zinc.

The liquor filtered from the precipitated sulphide of zinc contains the nickel, a portion of which metal is retained also in that from which both the zinc and nickel were precipitated by carbonate of sodium, as described in the preceding paragraph. The two liquors should therefore be mixed, and the whole of the nickel contained therein should then be precipitated by means of a solution of caustic potash, which produces a bulky apple-green precipitate of hydrate of protoxide of nickel. The whole should be heated, and the precipitate is then collected on a filter, washed with boiling water, dried, ignited, and weighed. 37·5 grains of oxide of nickel contain 28 of nickel, or one grain of oxide of nickel contains 0·7837 of nickel.

GIN. *See* BRANDY.

GLASS.—Glass is the generic name of the combination of silicate of potassium with one or more of the following silicates: namely, silicate of calcium, of magnesium, of aluminum, of barium of iron. But, besides these, several other ingredients are introduced; that in which silicate of calcium is replaced by silicate of lead is called *crystal*.

The specific gravity of glass varies according to the substance of which it is composed.

Bohemian-glass is a double silicate of potassium, and of calcium or aluminium. Its specific gravity is 2·396. Its constituents are—

Silica	71·6
Lime	10·0

Potash	11·0
Magnesia	2·3
Alumina	2·2
Oxide of iron	3·9
Oxide of manganese	0·2

Bohemian-glass is colourless, light, and, owing to the large proportion of silica which it contains, is extremely difficult to fuse; on which account it is preferable to any other kind of glass for certain purposes, particularly for chemical operations.

It is also the only glass that can be *stained* red, for when the process of staining in that colour is attempted with any other, the glass softens long before the metallic oxide employed to produce the red stain has been brought to the fusing point. The ingredients for the manufacture of Bohemian-glass are employed, it is said, in the following proportions:—

Quartz (hyalin) heated to redness, then quenched in cold water, and finely pulverized	100 parts
Calcined purified pearlash, of best quality	50 to 60 ,,
Calcined lime	15 to 20 ,,
Arsenious acid	¼ to ½ part.
Nitre	1 ,,

Crown-glass is also a silicate of potassium and of calcium, chiefly employed for the preparation of optical instruments, but likewise for best window-glass.

The specific gravity of crown-glass is 2·487, and its constituents are as follows:—

Silica	62·8
Lime	12·5
Potash	22·1
Alumina	2·6
	100·0

Crown glass should be perfectly clear, free from streaks or bubbles, and colourless. The proportions of the above ingredients used for making the best crown-glass are the following:—

Purified pearlash	250
Fine sand	300
Lime	33

Window-glass is generally a double silicate of sodium and of calcium, the soda being obtained from a mixture of sulphate of sodium and of charcoal, in the proportion of three parts of the first and one of the second. Its specific gravity is 2·642, and its composition is as follows:—

Silica	69·65
Lime	13·31
Soda	15·22
Oxide of iron	1·82
	100·00

The proportions of the substances employed for making window-glass are the following:—

Sand	100 parts
Dry sulphate of sodium	44 „
Pulverized charcoal	8·5 „
Slaked lime	6 „
Collet	20 to 100 „

Collet is old broken glass.

Plate-glass is a silicate of sodium and of calcium. Its specific gravity is generally 2·488, and its constituents are:—

Silica	75·9
Lime	3·8
Soda	17·5
Alumina	2·8
	100·0

Plate-glass should be very clear, transparent, and free from streaks, knots, and bubbles; it is obtained by fusing together the following substances:—

Very fine white sand	300 parts
Dry carbonate of sodium	100 „
Lime slaked by exposure	43 „
Collet	300 „

The above proportions and ingredients are those used for the manufacture of plate-glass at St. Gobin, in France; the materials of English plate-glass are said to be—

Fine sand	300 lbs.
Soda	200 „
Lime	30 „
Manganese	32 ounces.
Cobalt azure	3 „
Fragments of good glass	300 lbs.

Green bottle-glass contains a little potash or soda, but the proportion of lime, alumina, and oxide of iron is considerable a little manganese is present. Its specific gravity is 2·632, and its constituents are as follows:—

Silica	53·55
Lime	29·22
Potash and soda	5·48
Alumina	6·01
Oxide of iron	5·74
	100·00

The green colour of this kind of glass is due to the presence of oxide of iron which is reduced by the carbonaceous matter of the ingredients, and which forms a silicate of protoxide of iron. The brown colour of some kinds of bottle-glass is due to the presence of an intermediary oxide of iron; and that which has a yellowish colour, such as the bottles in which Rhenish wines are contained, owes its colour to the presence of peroxide of manganese and of oxide of iron.

The mixture employed for making bottle-glass in France, Belgium, and Germany, consists of—

Yellow sand	100	parts.
Kelp	30 to 40	„
Lexiviated wood-ashes	160 to 170	„
Fresh wood-ashes	30 to 40	„
Yellow clay	80 to 100	„
Collet	100	„

Crystal is a silicate of potassium and lead, the manufacture of which requires careful attention in the choice and purity of the materials, and in their manipulation. The silica employed should be as free from iron and organic subtance as possible, and it should be in very fine powder.

In order to ascertain the purity of the sand to be employed, it is best to expose it to a high temperature in contact with the air, during which the iron which it may contain becomes peroxidized, and imparts a reddish-brown tinge to the sand. The purest sand of course is that the colour of which is least altered, but it is almost impossible to meet with sand which contains no trace of iron, and which, consequently, remains unaltered by that treatment.

The carbonate of potassium used requires, likewise, to be carefully purified, which is done by dissolving it in water and evaporating, in order to crystallize and separate the sulphates and chlorides which it contains; the carbonate of potassium remaining in the mother-waters is recovered by evaporating the liquor to dryness.

Carbonate of sodium cannot be employed in the manufacture of crystal, because it imparts to the mass a greenish tinge, however pure the salt may be. This greenish colour is, in fact, one of the characteristics of soda-glass.

The lead employed for making the red lead used for the manufacture of crystal must be of the purest and best kind, for the presence of any other metal would be sure to impart a tinge to the crystal. The presence of oxide of copper is especially to be guarded against. The constituents of crystal are—

Silica	56
Lime	2·6
Potash	8·9
Oxide of lead	32·5
	100·0

The proportions usually employed are the following:—

In glass pots, heated with coals and covered—

Pure sand	300 parts.
Red lead	200 „
Purified carbonate of potassium	90 to 95

In glass pots, heated with charcoal as on the continent:—

Pure sand	300
Red lead	200
Purified carbonate of potassium	100
Fragments of good glass	300
Oxide of manganese	0·46
Arsenious acid	0·60

The two latter substances are employed for the purpose of oxidizing certain impurities, and especially the iron.

Flint-glass contains more oxide of lead than crystal. Its sp. gr. is 3·6. It should be very homogeneous, without bubbles, and colourless. It is employed in optics; lenses of flint-glass, combined with those of crown-glass, form achromatic lenses.

The constituents of flint-glass are:—

Silica	42·5
Lime	0·5
Potash	11·7
Alumina	1·8
Oxide of lead	43·5

Other specimens, according to Professor FARADAY, consist of—

Silica	51·93	48·24	44·30
Oxide of lead	33·28	40·12	43·05
Potash	13·77	10·60	11·75
Alumina	0·47	0·58	0·50
Oxides of iron, and of manganese	0·27	0·08	0·12
	99·72	99·62	99·72

The proportions of the materials employed in the manufacture of flint-glass are as follows:

Pure sand	300
Red lead	300
Potash	150
Nitre	10
Arsenious acid	0·45
Oxide of manganese	0·60

Analysis of Glass.—Take 100 grains of the glass previously reduced into very fine powder, and mix carefully with about 400 grains of dry carbonate of sodium, also in very fine powder; put the mixture into a platinum crucible, or capsule, and maintain it in a perfectly fused state for about half an hour. When cold, place the crucible containing the fused mass in a wide porcelain capsule, and carefully pour an excess of dilute hydrochloric acid upon it, whereupon all the oxides, earths, and alkalies, as well as the silica, will be dissolved. Wash the crucible clean and carefully evaporate the whole of the liquor, with whatever residuum it may contain, to dryness. When dry, increase the heat to above 500° or 600° Fahr., which will render the silica insoluble. The dry residuum must now be treated with acidified water, which re-dissolves the oxides, but which leaves the silica in an insoluble state. The latter is collected on a filter, washed, dried, ignited, and weighed.

The liquor filtered from the silica is then treated by an excess of solution of ammonia, by which the oxides of iron and the alumina are precipitated, whilst the lime remains in solution in the state of chloride of calcium. The precipitates of peroxide of iron and of alumina are separated by filtering, and washed. This being done, an excess of solution of caustic potash is poured on the washed precipitate, and the whole is boiled. The potash dissolves the alumina, but leaves the peroxide of iron in an insoluble state; it is collected on a filter, thoroughly washed with boiling water, dried, ignited, and weighed. The liquor filtered from the peroxide of iron, and which contains the alumina in solution (aluminate of potassium) should now be decomposed by supersaturating it with hydrochloric acid, and carbonate of ammonium being poured into it, the alumina is precipitated; it is then collected on a filter, washed, dried, ignited, and weighed.

The liquor which was filtered from the precipitate of peroxide of iron and of alumina, produced by ammonia, and which contains the chloride of calcium in solution, should now be treated by oxalate of ammonium, which precipitates the lime in a state of oxalate of calcium. This precipitate being collected on a filter, washed, and ignited, is then weighed as carbonate of calcium. 50 grains of carbonate of calcium represent 28 of lime, or each grain of carbonate of lime contains 0·56292 of lime.

The determination of the quantity of potash and of soda contained in glass is more difficult. The process which gives good results is that by treatment with hydrofluoric acid. Brunner's apparatus, which obviates the necessity of the use of a platinum retort, is the most convenient. The operation should be performed as follows:—Take a fresh portion of the glass to be analysed, previously reduced by levigation into exceedingly fine powder, weigh off 25 grains of it, put them in a platinum capsule, and drench with water; take now a flat-bottomed lead capsule, with a cover also of lead, about six inches in diameter, and two inches and a half high; place in the middle of it a small ring of lead, which may be easily made by bending a strip of lead about one inch, or an inch and a half in diameter, and one inch and a half thick; pulverized *fluor spar* should then be spread in the lead capsule, and concentrated sulphuric acid being poured upon it, the platinum capsule containing the pulverized glass, moistened with water, is immediately placed upon the ring of lead, and the leaden cover is placed over the whole. This being done, the heat of a small spirit-lamp is applied to the lead capsule; the hydrofluoric acid fumes evolved are absorbed by the water of the moistened and pulverized glass, and, reacting upon the glass, liberate fluoride of silicium. This experiment should be carried on under the hood of a chimney with a good draught, or in the open air. About two hours are required to complete the decomposition of the glass, during which time the mass should be now and then stirred, and moistened with a little water. When the decomposition is effected, the mass in the platinum capsule should be treated with sulphuric acid, and evaporated to dryness; dilute sulphuric acid is then poured upon the dry mass; this dissolves the potash, soda, alumina, oxide of iron, and a trace of lime. The solution being now treated by carbonate of ammonium, alumina, oxide of iron, and lime are precipitated, and separated by filtering. The liquor filtered therefrom being evaporated to dryness and slightly ignited, the residuum, which consists of sulphates of potassium and of sodium, is weighed, in order to obtain their collective weight; they are then redissolved by water, and a solution of chloride of barium is poured in, which converts the above sulphates into chlorides, and the white precipitate of sulphate of barium, produced by the reaction, is separated by filtering. The filtrate is concentrated by evaporation, and an excess of solution of chloride of platinum is poured into it, which precipitates the potassium in the state of double chloride of potassium and platinum; the whole being carefully evaporated nearly to dryness, alcohol is poured upon it, the precipitate is collected on a filter, washed with weak alcohol carefully dried at 212° Fahr., and it is then weighed. 247 grains of the double chloride of potassium and platinum represent 47 grains of potash. Or the following method (LAWRENCE SMITH) may be employed:—Mix intimately in a glazed mortar one part of the finely pulverized glass with five or six parts of carbonate of calcium, and half to three-fourths of pure chloride of ammonium; introduce the mixture into a platinum crucible, and heat to bright redness from thirty to forty minutes. There is no silicate which after having undergone this process is not easily dissolved by hydrochloric acid. For the action of the lime to have been complete, it is not necessary that the mass should have settled down to perfect fusion. The contents of the crucible are dissolved in dilute hydrochloric acid, and the solution evaporated to dryness; the operation may be completed over a lamp without the danger of the *spitting* which occurs when the fusion is made with soda. To the dry mass hydrochloric acid is added; it is then diluted and boiled; when cold, carbonate of ammonium is slowly added in excess, and the precipitate which occurs is filtered off. The filtrate contains chloride of ammonium, chlorides of calcium, and perhaps of magnesium, and the alkalies of the mineral. It is concentrated by evaporation, and nitric acid may be added in the proportion of about three parts to only one of chloride of ammonium; the latter is completely decomposed by the nitric acid at a low temperature, into gaseous products, and much trouble is avoided, the evaporation proceeding rapidly. When dry, the residue is dissolved in water, lime-water is added, and the liquid is boiled and filtered. To the filtrate a sufficient quantity of carbonate of ammonium is added to separate the lime, which is filtered off, and the filtrate is again evaporated to dryness. Dilute sulphuric acid is now added, by which the nitric and hydrochloric acids are expelled, and the alkalies remain in the form of sulphates. For the conversion of the alkaline sulphates into chlorides, acetate of lead is added in slight excess, in order to precipitate the sulphuric acid; the sulphate of lead is filtered off; the lead is removed from the filtrate by sulphuretted hydrogen, the sulphide of lead is filtered off, excess of hydrochloric acid is added to the filtrate, by which the acetates of the alkalies are converted into chlorides, and the liquid is evaporated to dryness. When the object is the quantitative estimation of the *alkalies* only, in the siliceous compound, the above operations may be considerably curtailed. After the glass under examination is perfectly decomposed by fusion with carbonate of calcium and chloride of ammonium, the mass is heated with water *alòne*, until thoroughly disintegrated, when it is thrown upon a filter and thoroughly washed. The filtrate contains merely the chlorides of the alkalies, a little chloride of calcium, and caustic lime. A small quantity of carbonate of ammonium is added to precipitate the two latter substances, the carbonate of calcium is separated by filtration, the filtrate is evaporated and simply ignited, and the residue consists of the alkalies in the shape of chlorides.

When the glass submitted to analysis contains oxide of lead, the pulverized mass, after fusion with carbonate of potassium, should be treated by nitric acid (instead of by hydrochloric acid) and evaporated to dryness, exactly as before mentioned, in order to render the silica insoluble; the mass is then treated by water and thrown on a filter, in order to separate the silica. A current of sulphuretted hydrogen must now be passed through the liquor, filtered from the insoluble silica, until it smells strongly of the gas; the black precipitate of sulphide of lead, which is thus produced, should be collected on as small a filter as possible, well washed and dried; it should then be put into a glass beaker along with the filter, and strongly fuming nitric acid cautiously poured upon it, in small portions at a time, for the action is violent, and a portion of the mass might otherwise be projected; the glass beaker should be kept covered with a capsule in order to guard against loss. The sulphide of lead is thus converted into sulphate of lead by the oxidizing action of the nitric acid, and a few drops of sulphuric acid may further be added. The sulphate of lead produced is moderately heated, until acid vapours cease to be evolved; it is then ignited and weighed.

Or the sulphide of lead precipitated may be treated by concentrated hydrochloric acid, which produces a disengagement of sulphuretted hydrogen, and the lead is then in the state of chloride. Nitric acid is then added, the whole is evaporated to dryness, the sulphate of lead so produced is ignited in a porcelain crucible and weighed. 152 grains of sulphate of lead represent 104 of lead.

GLASS OF ANTIMONY. *See* ANTIMONY.

GLUE.—Glue and size are made from the pieces of skin which are cut off by tanners as unfit for conversion into leather, or which are too small to be turned to any other account. The conversion of skins into glue or size is effected by boiling them in water, in large boilers or coppers provided with a grating at the bottom, and into which the pieces of skin, enclosed in a large net, lifted and lowered down by a crane, are immersed. The conversion of skin into glue is known only as a fact, but is not as yet well understood, for glue or gelatine does not exist ready formed in the animal tissue.

In the pure state glue is colourless, transparent, hard, and extremely cohesive; this cohesion or *strength*, however, is less considerable in that which has been obtained from bones and cartilage, the strongest being that derived from skins, and especially from ox and cow-hides.

The glue of commerce has ordinarily a yellow or brown colour from the coagulated albumen, and other extractive matter which it contains.

When a concentrated solution of alum is mixed with melted glue, the latter becomes whiter, and it thickens, the tenacity of the glue being thereby apparently increased and its colour improved, so that glue made from skins of an inferior quality may thus compete *to the eye* with that made of the best materials. Alum, however, is always added to a certain extent to glue, and largely to size, in order to clarify the liquor from which these substances are obtained, before they are poured in the moulds or into the firkins. Alum has also the property of preventing the size from turning mouldy. The addition is therefore so far beneficial, but it should not be overdone. Alum may be estimated in glue, after incinerating it, in the same way as described in the article on *Bread.*

A superior description of size is employed by paper-makers and paper-stainers. It is a colourless article, manufactured from hides which are macerated in water to incipient putrefaction; they are macerated in an aqueous solution of sulphurous acid, and then converted into size in the usual way.

GOLD.—*Analysis of Alloys of Gold.*—Several methods are employed. In the first place, an approximation to the relative proportions of the constituents is obtained by the touchstone and the assay-needle. The former is a black and polished basalt; black flint and pottery will serve the same purpose. The assay-needles are small fillets of gold, alloyed with different and known quantities of silver and copper. The sets may consist of pure gold; pure gold 23½ carats, with half a carat of silver;* 23 carats of gold, with one carat of silver; 22½ carats of gold, with 1½ carat of silver; and so on, till the silver amounts to four carats, after which the additions may proceed by whole carats. Other needles may be made in the same manner, with copper instead of silver, and other sets may have the addition, either of equal parts silver and copper, or of such proportions as the occasions of business may require. When a specimen of gold is about to be examined, it is rubbed on the touchstone, and the colour which it leaves is compared with that communicated to the stone by the assay-needles taken successively; that which leaves a mark most resembling that produced by the specimen, is in composition most nearly allied to it, and, as the composition of the needle is known, so the operator is enabled to judge of the quantity of silver necessary to be added for the *quartation* proof. The alloy is next cut into small thin plates, and fused in the cupel (see *Silver*), with 3½ times as much pure silver as it contains gold, and with three or four times its weight of lead. After the operation, the gold and the silver remain, the oxide of copper being absorbed with the oxide of lead by the cupel. This process is termed *quartation*, because the gold forms one-fourth part of the cupelled alloy, a proportion which admits of the complete subsequent extraction of the silver by the action of nitric acid. The alloy of gold and silver is next reduced to thin plates, weighed, and gently heated with nitric acid, diluted, and quite free from nitrous and hydrochloric acids; the silver dissolves, the gold remaining untouched. The acid being saturated, a stronger acid is added, and the solution is gradually brought to boil, by which the perfect separation of the silver is accomplished, the gold retaining still the form of the original plate. It is therefore easily weighed; previous to which, however, it must be washed with distilled water, as long as any traces of silver appear, by the test of common salt, and then heated to redness. The loss which the mass experiences by the process of cupellation indicates the quantity of copper contained in the alloy, and the proportion of silver is afterwards found by the action of the nitric acid. It must particularly be borne in mind that if the nitric acid be not free from nitrous acid, and especially from hydrochloric acid, a portion of the gold, sufficient to affect seriously the result of the assay, may be dissolved.

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* In estimating or expressing the fineness of gold, the whole mass spoken of is supposed to weigh 24 carats of 12 grains each, either real, or merely proportional, like the assayers' weights; and the pure gold is called fine. Thus, if gold is said to be 23 carats fine, it is to be understood that, in a mass weighing 24 carats, the quantity of pure gold amounts to 23 carats.

Mr. MAKIN has drawn attention to the loss which occurs in parting operations, and refining on a large scale, from the solution of gold in nitric acid, even when quite free from hydrochloric acid, in consequence of the formation of nitrous acid. When the silver is present in large quantity, the solvent action appears to be restrained by electrical action; but as the silver is removed, the solution of the gold goes on more rapidly. The cause of the evolution of nitrous acid is evident as long as there is any silver present, and it often results from the use of charcoal, to prevent "bumping." When charcoal is thoroughly carbonized, it does not materially affect the acid, but if it contain woody matter, nitrous acid is sure to be set free.

Purification of Gold by Cementation.—The alloy is reduced to a thin plate, and surrounded in a crucible with a pulverulent mixture of four parts of brick-dust, one of calcined vitriol, and one of common salt. It is then exposed for sixteen or eighteen hours to a strong red-heat. The vapours of hydrochloric and sulphuric acid which are formed attack the metals mixed with the gold, and the mass is prevented from fusing by the brick-dust. If the first cementation has not been found sufficient to purify the gold, the operation is repeated, but in the place of common salt nitre is used. The same method is employed to refine the surface of gold articles after they are polished. The cementation here produces the same effect as tartar and salt, in which silver goods are boiled to give them a white colour.

Purification by Fusion with Sulphide of Antimony.—Some borax is fused in a crucible, so that the walls become lined with the vitrified flux; a mixture of two parts of sulphide of antimony and one of the gold to be assayed is then introduced. The sulphur combines with the foreign metals, and the antimony unites with the gold; the alloy being removed, the scoriæ are a second time fused, with the addition of two parts more of sulphide of antimony, and, when the whole of the gold is extracted, the various alloys are mixed together and heated in an open vessel, with two parts of sulphur. The sulphide of antimony volatilizes, leaving the gold; to increase the action, a current of air from a pair of bellows may be directed on the surface of the melted mass, or, what is perhaps still better, the mixture of the two metals may be fused in a large crucible, with three times its weight of nitre, by which the antimony becomes oxidized and dispersed, the gold remaining untouched. Another method is to fuse the gold alloy with a mixture of *oxide of lead* and *sulphur*, and to add to the fused mass charcoal in the state of fine powder; the gold is thus obtained alloyed with the lead only, from which it may be separated by cupellation.

In this operation it frequently happens that some of the antimony remains alloyed with the gold, a plan for removing which has been suggested by Mr. WARINGTON ('Jour. Chem. Soc.,' vol. xiii. p. 33). It consists in employing about 10 per cent. of oxide of copper, and a small quantity of borax, with which the alloyed gold must be kept in a well fused state for half an hour. The result is a perfectly malleable gold, containing a small percentage of copper, and well fitted for the purpose of coinage.

Estimation of Gold by Standard Solutions (HENRY, 'Journ. de Pharm.' Jan. 1847).—This process—which was devised by the author in consequence of the difficulty which he experienced in appreciating very minute quantities of gold, either by weighing or by cupellation, in certain investigations in which he was engaged relative to the processes of gilding and silvering of ELKINGTON and RUOLZ—is founded on the principle that in a mixture of terchloride of gold, a basic salt, and copper—a quantity of the latter metal, equivalent to that of the gold, separated either in powder, or upon the object to be gilt—is dissolved. When the amount of gold upon a gilt object, or in a bath which has been, or is to be employed in gilding, has to be ascertained, the following plan may be adopted:—the objects, weighed, with care, are digested with hot pure nitric acid; as soon as the copper forming the basis is dissolved, the solution is diluted with distilled water, and the gold is soon seen to settle at the bottom of the vessel in small brilliant scales. These are collected, and, after washing, dissolved in aqua regia; the solution is evaporated with great precaution nearly to dryness, so as to obtain a ruby-red product, soluble in water; this is terchloride of gold with a little acid. This product is now dissolved in distilled water, and mixed with five or six times its weight of pure bicarbonate of potassium or sodium, dissolved in distilled water; the mixture is heated, conveyed into a ground-stoppered flask, and a somewhat large amount of finely divided copper, which has been previously heated in a current of hydrogen, added to it; the mixture is now and then shaken, and after about an hour the liquid assayed. A very minute quantity of the liquid is poured upon a watch-glass and treated with protosulphate of iron; if the liquid does not yield a black or grey precipitate, it is a sign that it contains no gold in solution; should the contrary occur, more copper must be added, and the liquid again agitated. When the whole of the gold has been precipitated upon the copper, the liquid is carefully saturated with pure sulphuric acid, so as to be *slightly acid.* By this means all the copper precipitated in the state of *carbonate* is dissolved, without the gold or *metallic copper* being at all acted upon. It is filtered, and a solution of pure *ferrocyanide of potassium* of known strength carefully added by means of a graduated burette, until a precipitate ceases to be formed; the number of divisions of the instrument employed to precipitate the copper is noted, and in this manner the quantity of the metal dissolved in the liquid is ascertained.

When it is a solution which is to be, or has been, used for gilding, the author advises to precipitate the diluted acid solution by a current of sulphuretted hydrogen, to collect the precipitate and strongly calcine it after washing. The sulphide of gold being reduced to the metallic state, the calcined residue is redissolved in nitric acid, and the gold which has remained unattacked dissolved in aqua regia, and treated as above described.

The use of the ferrocyanide of potassium, to determine the amount of copper which represents the gold in a compound, is founded on the fact that this reagent is still very sensitive when sulphide of sodium has no longer any perceptible action. The conditions requisite for the success of the operation are:—1st, to take care that the copper employed is perfectly *free* from oxide; 2nd, to be certain that, after contact with the copper, no gold remains in solution; 3rd, to saturate the mixture exactly with pure sulphuric acid after the reaction; 4th, to mix as quickly as possible, at a gentle heat, the copper and the bicarbonate with the solution of the terchloride of gold; 5th, to add the test liquid, which has been made shortly before use, with precaution, and only by drops, when but a slight chestnut or dark-red precipitate is produced.

M. Henry quotes a number of experiments, the results of which prove the exactness of the process, as well as the ease and quickness with which it may be performed.

GREY AMBER. *See* Ambergrease.

GREY COBALT ORE. *See* Cobalt Ores.

GUANO. *See* Manures.

GUINEA PEPPER. *See* Capsicum.

GUM ARABIC. Gum arabic exudes from several species of trees in Egypt and Arabia; that from the *Acacia Arabica* is the best. It is in rounded pieces, of an irregular size, hard, brittle, semi-transparent, colourless, or of a slightly yellowish or brownish colour, due to the presence of foreign substances. Gum arabic is odourless, and has only a faint flavour. When pure, it is entirely soluble in water, but more rapidly in hot water. Its specific gravity varies from 1·31 to 1·48, or 1·515. In the dry state, gum arabic retains still 17 per cent. of water, which may be eliminated by pulverizing it and exposing the powder for a long time to a steam heat.

Gum arabic is often adulterated with *gum senegal*, which has almost the same appearance, and altogether the same qualities as gum arabic; but as gum arabic is always a little more expensive, the best pieces of gum senegal, that is, those which are small and of a light colour, dry, easily broken—and in fact, which resemble gum arabic most—are mixed with it, and sold as such. It is sometimes mixed also with common cherry-tree gum. The means of detecting this fraud are given in the article on *Gum Senegal.*

Gum arabic is often sold in a pulverized state; the gum sold in that state, and under that name (pulvis acaciæ) is a white powder, but which is frequently mixed with starch or flour, and in which generally the gum arabic is altogether replaced by gum senegal, or partly by pulverized cherry-tree gum. The adulteration with starch or flour, however, is very easily detected by putting a small quantity of the suspected gum into cold water, and stirring the whole for a while. The gum dissolves rapidly, whilst the starch or flour falls to the bottom of the vessel.

The presence of starch and of flour may also be detected by boiling a small quantity of the suspected gum in water, and testing the mucilage, after it has become quite cold, with the tincture, or with an aqueous solution of iodine, which will immediately impart an intense blue colour to the mass.

GUM LAC. *See* LAC.

GUM SENEGAL.—Gum senegal is produced by the *Acacia senegalensis*, and has the same properties as gum arabic, the only difference being that gum senegal is in larger masses and of a darker colour, very hard, of a vitreous fracture; the lumps are often superficially covered with sand, which, however, is easily removed by washing them with water, and immediately drying them.

Gum senegal is often, like gum arabic, mixed with common cherry-tree gum, which resembles gum senegal. Common cherry-tree gum, however, is generally in irregular masses of a dark brown colour, difficult to break, and when thrown into water they swell and separate in insoluble gelatinous clots; and if they be thrown on a filter, and the filtrate be evaporated, it will be seen that a small portion only has been taken up by the water. When pulverized, the presence of the common gum is recognized, because the mucilage, which the powder forms with water, instead of being homogeneous and syrupy, is more or less interspersed with gelatinous clots.

GUM TRAGACANTH.—Gum tragacanth is produced by the *astragalus creticus*; it is met with in thin, opaque, white or yellowish, tough, flat strips of an irregular shape, or in threads, or in amorphous lumps, tasteless and odourless.

This gum has nearly the same properties as gum arabic or senegal, but it is partly insoluble in cold water, though entirely soluble in boiling water. One part of gum tragacanth forms as thick a mucilage as 25 parts of gum arabic.

Gum tragacanth, in the state just described, can hardly be adulterated; but in the pulverized state it is very often mixed with a multitude of other cheaper powders, more especially with gum senegal.

A mixture of pulverized gum tragacanth and gum senegal always forms with water a thinner mucilage than the same quantity of either of these gums alone. The following process is indicated, by M. PLANCHE, for the detection of this fraud :—Make a mucilage of the suspected gum, and add thereto a few drops of alcoholic tincture of guaiacum, taking care to stir all the while. If the gum under examination contain any gum arabic, the mixture, in the course of a few minutes, assumes a fine blue colour, whilst it does not change colour if the gum tragacanth be pure. One-twentieth part of gum arabic can be thus detected.

We should remark, that only four or five drops of tincture of guaiacum should be employed for two drachms of mucilage, and that when the quantity of gum arabic is very small, three or four hours must often elapse before the change of colour can be observed.

And, moreover, when rectified alcohol is poured in a clear and filtered mucilage of gum tragacanth, it produces only a few flakes, which swim about in the liquor, but do not impair its transparency; whilst if gum arabic is present, either a precipitate is produced in the liquid, or it becomes opalescent, according to the proportion of gum arabic which it contains.

GUN METAL. *See* BRONZE.

GUNPOWDER.—Gunpowder is essentially a mechanical but very intimate mixture of three substances : namely, saltpetre, charcoal, and sulphur, in various proportions, according to the use for which it is intended, and according to the country where it is manufactured. The following Table indicates the composition of gunpowder in several countries :—

		Saltpetre	Charcoal	Sulphur
England	Common powder	75·0	12·50	12·50
	Waltham Abbey Mills	75	15	10
	Shooting powder	78	12	10
		76	15	9
	Priming powder	65	15	20
France	National Mills	75	12·50	12·50
	Shooting powder	78	12	10
	Mining powder	62	18	20
America	Common powder	75	12·50	12·50
Prussia	” ”	75	12·5	12·5
Russia	” ”	73·78	13·59	12·63
Austria	” ”	76	11·50	12·50
Spain	” ”	76·47	10·78	12·75
Holland	” ”	70·00	14·00	10·00
Sweden	” ”	75	9	16
Switzerland	” ”	76	14	10
China	” ”	75	14·40	9·60
Bavaria	” ”	75	12·5	12·5
Baden	” ”			

Under the influence of a sufficient degree of heat, the three constituents of gunpowder react powerfully upon each other, and disengage almost instantaneously an enormous quantity of gas, on which the dynamic effect of this compound depends. If the heat be communicated to the powder by a spark, the charcoal first catches fire, then the sulphur, and lastly the saltpetre is decomposed into potash, nitrogen, and oxygen. A small portion of the potash is decomposed by the carbon into potassium, water, and oxygen; the oxygen combining with the sulphur produces sulphurous acid, part of which escapes, whilst another portion combines with a part of the potash to form sulphite of potassium, which is left as a residue. A portion of unconsumed sulphur remains also as a residue, but another portion combines with the potassium, and forms a residue of sulphide of potassium. The carbon yields carbonic oxide and carbonic acid gases; a portion of carbon is left as a residue. A portion of the carbonic acid combines with the potash, and gives a residue of carbonate of potassium; the excessive heat produced by the combustion of the powder decomposes the nitric acid into nitrogen and oxygen, and converts the water into steam. The explosion carries off a portion of the residue in the form of smoke. Other compounds formed are sulphuretted hydrogen, carburetted hydrogen, sulphide of carbon, sulphate of potassium, and cyanide of potassium.

Aqueous vapour, though appearing amongst the gaseous products, is always in very small quantity, and its presence is owing to the property which charcoal powder possesses of absorbing moisture, on account of its porosity, and in consequence of which gunpowder, even of the very best quality, and kept in the driest magazines, is never perfectly dry. The moisture penetrating the grains of powder, proportionately impairs its dynamic or ballistic effects, causes the saltpetre to effloresce at the surface of the grains, destroys the homogeneity of the mixture, and disaggregates its constituents. The gunpowder which has been made with black charcoal absorbs less moisture, and this is the case also with large-grained more than with small-grained powder. In dry magazines ordinary gunpowder contains from 0.5 to 0.6 per cent. of moisture, but if left exposed in damp places, it absorbs a much more considerable quantity of it. Large-grained powder, and that which is damp, leave in the gun a thick coating, which augments at each round, and soon renders the gun so foul as to become useless until cleaned.

The temperature produced by the combustion of gunpowder is exceedingly high, and sufficient to melt gold and red copper; the gases produced by the combustion are thus enormously dilated, and, according to GAY-LUSSAC, one volume of gunpowder produces about 2000 volumes of gas; but in order to obtain the fullest effect the combustion must take place very rapidly, and therefore the dynamic effects of gunpowder depend not only upon the proportions of the substances employed, but likewise upon their intimate mixture, and on the physical state of the powder after being manufactured.

Gunpowder should be hard enough not to give a large quantity of dust by abrasion, for the dust lying compactly impedes the rapidity of the inflammation. Good gunpowder should resist pressure between the fingers, and after spreading upon the back of the hand it should leave no stain thereon. The grains should have a slightly shining or glossy appearance, and be proportional to the use for which it is intended.

The grains of ammunition gunpowder should be angular, hard and dry; they should be able to resist a moderate pressure, and give no dust when poured in the hand.

The grains of shooting gunpowder should be angular, hard, of uniform size, and glossy.

Miners' powder is similar to that used for cannon.

Good gunpowder, being spread upon a sheet of paper and inflamed, should burn rapidly with a flash, and should leave no appreciable residue on the paper; neither should it burn it.

Gunpowder has generally a dark greyish or brownish colour; a perfectly black colour indicates that either too much charcoal has been used, or that the charcoal was too hard. If the grains exhibit here and there white sparkling particles, they are due to an efflorescence of the saltpetre, and they are generally observable on powder which, having been accidentally wetted, has been redried.

When gunpowder does not contain more than 7 per cent. of water, it may be rendered again perfectly good by drying it; but when it contains 8, 10, or 14 per cent. of water, as is sometimes the case, it should be remanufactured. As, however, the gunpowder which has become wet may have lost a portion of its saltpetre, it is necessary to analyze it in order to ascertain and, if necessary, to restore the loss. When damaged by sea-water, it is no longer fit for use, but from such powder the saltpetre may be extracted.

Analysis of Gunpowder.—The sample intended for analysis (from 20 to 30 grains) is finely pulverized and dried, either in the water-bath, or *in vacuo* over sulphuric acid. It is then digested for some time with boiling distilled water, and the insoluble portion thrown on a filter, the weight of which is known. It is repeatedly washed while on the filter with hot water. The filtrate and the washings are evaporated to dryness, and the dry mass estimated as nitre; or, after having weighed the residue, it may be redissolved in water, and tested for common salt by nitrate of silver, and if any notable quantity is thereby indicated, the silver salt must be added as long as any precipitation takes place, and the resulting chloride of silver calculated into its equivalent of chloride of sodium, 143·5 grs. chloride of silver = 58·5 grs. chloride of sodium, and the amount deducted from the dry salt. The substance remaining on the filter is dried and weighed; it consists of carbon and sulphur. To determine the proportion of these two elements, a fresh quantity (from 15 to 20 grains) of the finely powdered sample is intimately mixed with an equal amount of pure anhydrous carbonate of sodium; the mass is then mixed with about eight parts of nitre and six of common salt. The whole is strongly heated in a platinum crucible: the sulphur becomes thereby oxidized into sulphuric acid at the expense of the oxygen of the nitric acid, and the acid thus formed unites with the potassa of the decomposed nitre, forming sulphate of potassium. As soon as the mass has become white, it is dissolved in water, acidified with hydrochloric acid and the sulphuric acid precipitated by chloride of barium; from the weight of sulphate of barium obtained the amount of sulphur is calculated.

Marchand modifies the above (Gay-Lussac's) method of estimating the sulphur in gunpowder in the following manner:—A mixture of 1 part of nitrate and 3 parts of carbonate of barium is intimately mixed with a twelfth part of the powder, and heated in a tube closed at one end. A layer from 3 to 4 inches in length of barium salt is inserted in front of the mixture, and the whole is heated in the combustion-furnace, beginning at the anterior portion. The mixture, which does not fuse, is easily removed from the tube, which is rinsed with dilute hydrochloric acid, in which the ignited mass is then dissolved. The liquid is retained in a beaker for several hours near 212°, and the sulphate of barium is then collected on a filter. The amount of sulphur may likewise be determined accurately in the moist way. From 30 to 40 grains of the powder are treated in a flask with concentrated nitric acid, with the addition of a few grains of chlorate of potassium; the mass is kept gently boiling until, at last, a colour less liquid is obtained, which is diluted with a large quantity of water, and precipitated while hot with chloride of barium.

MM. Clöez and Guignet employ as an oxidizing agent pure crystallized permanganate of potassium. About one gramme of the well-dried powder is boiled with a saturated solution of the permanganate, fresh portions being added from time to time, until the mixture has a persistent violet colour: concentrated hydrochloric acid is then added, and the whole boiled until the oxide of manganese is completely dissolved; the solution is filtered, concentrated (if necessary), a little nitric acid added, and the sulphuric acid precipitated by chloride of barium.

The charcoal is estimated *indirectly* by deducting the weights of the moisture, nitre, and sulphur from the original weight of the powder analysed.

The amount of nitre in gunpowder may, according to Marchand, be ascertained with great precision by determining the quantity of nitrogen in the powder. For this purpose a portion of the sample is weighed off, reduced to a fine powder, and intimately mixed with oxide of copper; the mixture is transferred to a combustion-tube, the sealed end of which is charged with carbonate of lead, and then with oxide of copper; oxide of copper and metallic copper are placed in front.

Uchatius emoloys the following ingenious process for determining the amount of nitre:—20 grammes of the powder are introduced into a flask with about 50 grains of lead shot; 200 grammes of well-water are then added by means of a graduated pipette; the flask is well closed and shaken for eight minutes, by which the solution of the nitrate of potassium in the powder is completely effected. The solution is filtered, and 172 grammes of the filtrate measured off in a second pipette, and placed in a narrow beaker; it is brought to the normal temperature, and a glass bubble is introduced. This bubble is so constructed that when the powder contains 75 per cent. (= 15 grammes of nitrate of potassium) it will rise to the surface, while the addition of three or four drops of water will cause it to sink to the bottom. By means of a graduated pipette fixed quantities of one or two solutions are added, so as to cause an increase or diminution in the quantity of nitrate of potassium contained in the solution, equal to one or more 10ths per cent. until the bubble attains the surface of the solution. The percentage quantity of nitre in the gunpowder is now ascertained by adding to, or deducting from, 75, the amount of diminution or increase in the strength of the solution effected by the addition of the test fluid.

Separation of the Sulphur from the Charcoal.—For this purpose MARCHAND adopts WÖHLER'S method, which is as follows:—A weighed quantity (about 20 grains of the dried mixture of sulphur and charcoal) is introduced into a bulb blown out about 2 inches from the extremity of a tube of hard glass, about 8 inches in length. An asbestos plug is thrust into the longer part of the tube to within half an inch or so of the bulb, and the remainder of the tube is then filled with metallic copper; the tube is then weighed, a current of dried carbonic acid gas is passed through the tube, and the part containing the copper having been raised to a full red-heat, the sulphur is distilled through it; the sulphur vapours combine with, and are retained by, the copper. When the operation is over, the tube is allowed to cool; it is cut off between the asbestos plug and the bulb, and the latter, containing the carbon, is rapidly weighed; the loss of weight expresses the amount of sulphur. The heat which must be applied to remove the whole of the sulphur from the charcoal is, in general, greater than that at which the charcoal had been prepared, and there is observed during the expulsion of the sulphur a strong odour of humic acid; carbonic acid, carbonic oxide, and water are also expelled. Instead of distilling the sulphur from the charcoal, it may be removed by solvents. MARCHAND employs for this purpose *sulphide of carbon.* After exhausting the gunpowder with water, which he effects in a displacement apparatus of the form of an ordinary chloride of calcium tube, from 7 to 8 inches long, the bulb being stopped with asbestos, he treats it with absolute alcohol, which displaces the water, upon which sulphide of carbon, which has been rectified over oxide of lead, is poured over it until what passes through leaves no sulphur on evaporation; the powder is then finally treated with alcohol. It is still better to use the sulphide of carbon mixed with absolute alcohol. As soon as the charcoal is washed, a current of dry air is drawn through the tube by means of an aspirator, the tube itself being confined in an air-bath at 248°. The dry charcoal is weighed accurately in the tube.

The sand, &c., contained in the powder may be determined with tolerable accuracy by trituration and suspension.

HAMBURG WHITE. *See* CARBONATE OF LEAD.

HARTSHORNE (SPIRITS OF). *See* AMMONIA.

HEMATITE. *See* IRON ORES.

HONEY.—Honey is a saccharine substance produced by the bee, of a semi-solid consistence, white, yellow, or brown, and sometimes of an aromatic taste; brown honey has generally an acrid, disagreeable flavour.

The best way of purifying honey is the following:—Dissolve the honey to be purified in its own weight of water, and boil the whole four or six times, without skimming. It should then be removed from the fire, and after cooling it is poured upon linen strainers, previously covered with fine and well-washed white sand about one inch thick. The solution of honey which filters through has then the colour of white wine; the sand on the strainers is rinsed with cold water, and the liquor is finally evaporated to the consistence of syrup.

Honey is sometimes adulterated with chalk, but more often with flour, or with syrup of potato-sugar (glucose).

These sophistications are easily detected and estimated by dissolving a given weight of the honey in cold water; the chalk or other insoluble substances will settle at the bottom, and may be separated by decantation; in this way the chalk and the flour will settle, the chalk falling first. If the addition of hydrochloric acid produces an effervescence, it indicates the presence of chalk; if solution of iodine imparts a blue colour, it is owing to the presence of starch or flour.

If potato-sugar is present in the honey, it may be detected by the processes which are described in the article on *Sugar*.

Honey which has been kept more than a year, or which has become of a syrupy consistence, or of an acidulous or pungent taste, should be rejected. It is with the view of shielding this deterioration that flour or starch is often mixed with it. When honey which has been sophisticated in this manner is heated, it liquefies at first, but on cooling it becomes solid and tough.

HYDRAULIC CEMENTS. *See* LIME.

HYDRAULIC MORTARS. *See* LIME.

HYDRIODATE OF POTASH. *See* IODIDE OF POTASSIUM.

HYDROCHLORIC ACID (Chlorhydric Acid, Muriatic Acid, Spirit of Salt).—Hydrochloric acid is a combination of hydrogen and of chlorine. Hydrochloric acid is a gas produced by the action of sulphuric acid upon common salt, which gas, when condensed in water, constitutes the liquid hydrochloric or muriatic acid of commerce.

Commercial hydrochloric acid is a liquid of a yellow colour, of specific gravity 1·16 or 1·17, of a pungent, suffocating odour, intensely acid, and emitting white fumes in the air, especially if the air be damp. It is completely volatilized by heat. Pure hydrochloric acid is perfectly colourless.

As the specific gravity of hydrochloric acid is sometimes artificially increased by the fraudulent addition of certain salts, the specific gravity is no criterion of its genuineness or strength, except it be known that the acid is pure. The presence of fixed salts, however, may be summarily ascertained by evaporating to dryness a certain quantity of the acid under examination, which will leave the salts as a dry residuum, the relative proportion of which may at once be ascertained by weighing.

The proportion of real acid contained in a given sample may be correctly estimated by determining the saturating power. The manner in which this can be accomplished has been described in the article on *Acidimetry*; that is to say, by using a test-liquor of ammonia, or of carbonate of sodium of a known strength, or by ascertaining the quantity of carbonate of calcium which may be required to saturate the acid. This may be done as follows:—Take a given weight of the acid to be examined—for example, 100 grains—pour them into a somewhat large glass beaker, and dilute them with two or three times their weight of water. Take now a lump of white marble, more than sufficient to saturate the acid, weigh it accurately, and immerse it into the diluted acid in the glass beaker. An effervescence immediately takes place, and the lump of marble should be left in the acid until the effervescence has completely ceased; the lump of marble is then withdrawn, washed, dried, and weighed again; the difference indicates, of course, the quantity dissolved. Now, since 37 grains of pure hydrochloric acid can saturate 50 of carbonate of calcium (marble), it is clear that if the 100 grains of hydrochloric acid tested have dissolved, for example, 45 grains of carbonate of lime, the acid contained 33·3 grains per cent. of real acid, or 84 per. cent. of

Acid of 1·20 in 100	Specific Gravity	Chlorine	Muriatic Gas	Acid of 1·20 in 100	Specific Gravity	Chlorine	Muriatic Gas
100	1·2000	39·675	40·777	50	1·1000	19·837	20·388
99	1·1982	39·278	40·369	49	1·0980	19·440	19·980
98	1·1964	38·882	39·961	48	1·0960	19·044	19·572
97	1·1946	38·485	39·554	47	1·0939	18·647	19·165
96	1·1928	38·089	39·146	46	1·0919	18·250	18·757
95	1·1910	37·692	38·738	45	1·0899	17·854	18·349
94	1·1893	37·296	38·330	44	1·0879	17·457	17·941
93	1·1875	36·900	37·923	43	1·0859	17·060	17·534
92	1·1857	36·503	37·516	42	1·0838	16·664	17·126
91	1·1846	36·107	37·108	41	1·0818	16·267	16·718
90	1·1822	35·707	36·700	40	1·0798	15·870	16·310
89	1·1802	35·310	36·292	39	1·0778	15·474	15·902
88	1·1782	34·913	35·884	38	1·0758	15·077	15·494
87	1·1762	34·517	35·476	37	1·0738	14·680	15·087
86	1·1741	34·121	35·068	36	1·0718	14·284	14·679
85	1·1721	33·724	34·660	35	1·0697	13·887	14·271
84	1·1701	33·328	34·252	34	1·0677	13·490	13·863
83	1·1681	32·931	33·845	33	1·0657	13·094	13·456
82	1·1661	32·535	33·437	32	1·0637	12·697	13·049
81	1·1641	32·136	33·029	31	1·0617	12·300	12·641
80	1·1620	31·746	32·621	30	1·0597	11·903	12·233
79	1·1599	31·343	32·213	29	1·0577	11·506	11·825
78	1·1578	30·946	31·805	28	1·0557	11·109	11·418
77	1·1557	30·550	31·398	27	1·0537	10·712	11·010
76	1·1536	30·153	30·990	26	1·0517	10·316	10·602
75	1·1515	29·757	30·582	25	1·0497	9·919	10·194
74	1·1494	29·361	30·174	24	1·0477	9·522	9·786
73	1·1473	28·964	29·767	23	1·0457	9·126	9·379
72	1·1452	28·567	29·359	22	1·0437	8·729	8·971
71	1·1431	28·171	28·951	21	1·0417	8·332	8·563
70	1·1410	27·772	28·544	20	1·0397	7·935	8·155
69	1·1389	27·376	28·136	19	1·0377	7·538	7·747
68	1·1369	26·979	27·728	18	1·0357	7·141	7·340
67	1·1349	26·583	27·321	17	1·0337	6·745	6·932
66	1·1328	26·186	26·913	16	1·0318	6·348	6·524
65	1·1308	25·789	26·505	15	1·0298	5·951	6·916
64	1·1287	25·392	26·098	14	1·0279	5·554	5·709
63	1·1267	24·996	25·690	13	1·0259	5·158	5·301
62	1·1247	24·599	25·282	12	1·0239	4·762	4·893
61	1·1226	24·202	24·874	11	1·0220	4·365	4·486
60	1·1206	23·805	24·466	10	1·0200	3·968	4·078
59	1·1185	23·408	24·058	9	1·0180	3·571	3·670
58	1·1164	23·012	23·650	8	1·0160	3·174	3·262
57	1·1143	22·615	23·242	7	1·0140	2·778	2·854
56	1·1123	22·218	22·834	6	1·0120	2·381	2·447
55	1·1102	21·822	22·426	5	1·0100	1·984	2·039
54	1·1082	21·425	22·019	4	1·0080	1·588	1·631
53	1·1061	21·028	21·611	3	1·0060	1·191	1·224
52	1·1041	20·632	21·203	2	1·0040	0·795	0·816
51	1·1020	20·235	20·796	1	1·0020	0·397	0·408

hydrochloric acid of sp. gr. 1·20. Such an acid should have a specific gravity of 1·17.

When, however, the acid is known to be pure, which may be ascertained as described further on, its strength may be determined by its density, as shown in the Table (see p. 199) by Dr. URE, which we reproduce here.

Commercial hydrochloric acid is occasionally sophisticated, but it is moreover contaminated generally by various substances, the presence of which it is sometimes important to know how to detect. For example, it ordinarily contains all the salts which existed in the water which had been employed for condensing the gas, and likewise sulphurous and sulphuric acids, more or less; perchloride of iron; sometimes, also, a little arsenious or arsenic acid, nitric acid, and some free chlorine.

The presence of sulphurous acid is due to the action of the sulphuric acid upon the organic matter contained in the common salt employed in the manufacture of hydrochloric acid; but it is more especially on the Continent that this contamination is met with, for common salt being there subject to a fiscal tax, from which that salt is only exempted which is employed for manufacturing purposes, the government require that such salt should be mixed with tar or coal-dust. In Great Britain, sulphurous acid is found in hydrochloric acid when it has been manufactured from the salt which comes from the cod fisheries. Sulphurous acid, however, may also proceed from the bisulphate of sodium which is produced by the action of the sulphuric acid upon the salt, and which, being decomposed by the heat to which the retort is submitted, especially towards the end, is transformed into neutral sulphate of sodium, sulphurous acid, oxygen, and anhydrous sulphuric acid.

The presence of *sulphurous acid* is easily detected by diluting a small portion of the hydrochloric acid with water, and adding *an excess* of chloride of barium, in order to precipitate the sulphuric acid which may exist in the acid; this precipitate is separated by filtering, nitric acid is added to the filtrate, and the whole is then boiled. The sulphurous acid which may be present in the liquor being thus oxidized by the nitric acid, is thereby transformed into sulphuric acid, which, combining with the excess of chloride of barium in the liquor, produces again a white precipitate of sulphate of barium, which may be separated by filtering; and from which, after washing, drying, and ignition, the quantity of sulphurous acid may be estimated. 117 of sulphate of barium represent 32 of sulphurous acid. If the proportion of sulphurous acid is considerable, it may be detected by its odour (that of burning sulphur).

The presence of *sulphurous acid* in hydrochloric acid may also be detected by means of a solution of permanganate of potash. The process is as follows:—The acid in question is first diluted with water, and a few drops of the solution of permanganate of potassium are poured into it. If the colour of the permanganate is completely destroyed, sulphurous acid is present, for otherwise the solution would assume, for a certain length of time, a red or pink tinge.

The presence of *sulphurous acid* may also be detected by passing a current of sulphuretted hydrogen through the hydrochloric acid, for in that case a milky white precipitate of sulphur is produced. If the precipitate so produced is yellow, *arsenious* or else *selenic acid* may be suspected.

But, according to Messrs. FORDOS and GELIS, the smallest traces of *sulphurous acid* in hydrochloric acid may be detected as follows:—Dissolve a little zinc in the acid under examination, and pass the hydrogen gas which is evolved through a solution of subacetate of lead; or, better still, through one of oxide of lead in caustic potash; a black precipitate of sulphide of lead will then be produced.

The presence of *perchloride of iron* is easily detected by supersaturating the hydrochloric acid under examination with ammonia, which will precipitate the peroxide of iron in the shape of flakes of a reddish-brown colour, either immediately, or, if in trifling quantity, after a little time.

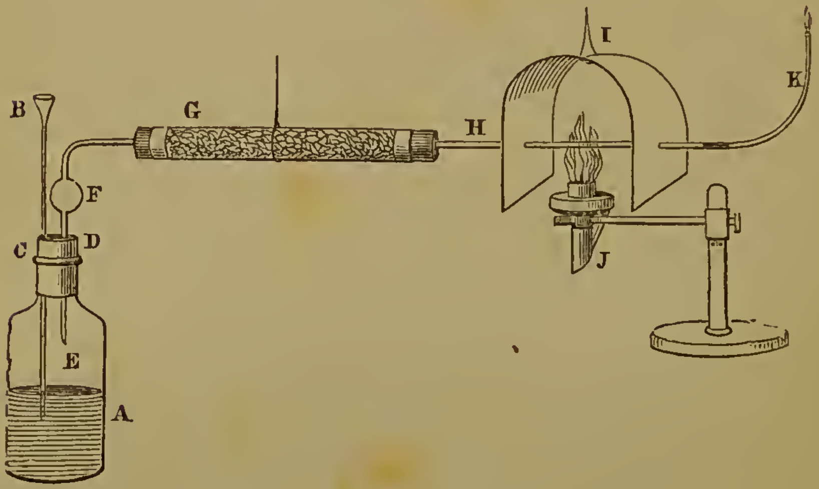
If, however, only traces of iron are present, it is better to supersaturate the acid with ammonia, and then to add hydrosulphuret of ammonia, which will precipitate the iron in the state of black sulphide. The yellow colour of the commercial acid is generally, though not always due to the presence of iron, but it may be also derived from contamination with organic matter; for example, from the lute with which the carboys containing it are closed, and portions of which have accidentally fallen into it. The presence of organic matter is readily detected by evaporating a few drops of the acid to dryness; a carbonaceous residuum will then be left.

The presence of arsenious acid is detected by MARSH's apparatus.

"*Marsh's Apparatus.*"—This instrument is grounded upon the property which nascent hydrogen has of combining with arsenic, with which it forms arseniuretted hydrogen, from which arsenic can be separated.

The apparatus represented in Fig. 20 is a modification of Mr. MARSH's original apparatus, whereby several sources of error and inconvenience are avoided; whilst, at the same time, it is rendered much cheaper, since it may at once be made with the bottles and tubes which are always to be found in the laboratory.

FIG. 20.



A is a bottle into which the acid solution to be examined for arsenic is put, together with pieces of pure zinc. B is a glass funnel passing through the cork C, and plunging in the liquid to be examined. C is a cork perforated with two holes for the introduction of the glass funnel B and the tube D. D is a glass tube bevelled at the end E, and to which a bulb, F, has been blown, in order that any water which may have escaped with the gas being condensed may readily fall back into the flask or bottle A. E, bevelled end of the tube D. F, bulb blown in the tube D, and into which the moisture of the gas is condensed. G, larger tube filled loosely with asbestos or cotton, in order to sift the gas as it passes through, thus preventing any particles of zinc or other metals from being carried further by the gas. H, tube of hard glass inserted in the larger tube G, and through which the gas ultimately passes; it is drawn into a point at K, for the purpose of inflaming the gas there. I is a sheet of copper through which the tube H passes, and the object of which is—First. To support the tube, as it might bend by being heated by the spirit-lamp J. Secondly. To reflect the heat of the lamp on that part of the tube. Thirdly. To keep the portion of the tube before and after its entrance in the copper sheet sheltered from the heat, and therefore cool. J, spirit-lamp. K is the end of the tube H drawn to a point.

The apparatus being thus disposed, and containing the pieces of pure zinc in bottle A, some water should be poured in sufficient quantity to stop the end of the glass funnel B, and then the hydrochloric acid under examination is introduced. Hydrogen is generated, which is allowed to escape for some time, so that the whole apparatus is filled with it. It may then be inflamed at the end, and a piece of glass, or china, or mica, being introduced into the flame at the end K, will show whether the zinc employed is pure; as, if so, the piece of glass, or china, or mica, will remain spotless.

As the zinc employed for the apparatus must, of course, contain no arsenic, the following method of purifying it for the purpose has been proposed by M. MICHELET: —

Melt some commercial zinc, and when very hot pour it out into a deep pail of water. Gather the zinc thus granulated, and if not in sufficiently small pieces, break the larger bits in a mortar, and place them in alternate layers with one quarter of their weight of saltpetre into a Hessian crucible, taking care to begin with a layer of saltpetre and terminate with a layer of zinc. Heat now the crucible, and when the deflagration and fusion will have taken place, remove the scoriæ, and run the zinc in an ingot mould; it will be found to be perfectly pure.

Caution.—It is necessary to wait some little time before inflaming the gas at K, in order that the apparatus may contain nothing but hydrogen; as if atmospheric air was still in it, an explosion might take place, which would break the apparatus.

Having thus ascertained that the zinc and materials employed are pure, the hydrochloric acid, being first diluted, so that it be only moderately acid, is to be introduced into the bottle A, by means of the funnel B.

The gas escaping at K may now be inflamed, which, if nothing but pure hydrogen is escaping, will burn with the ordinary flame peculiar to that gas; but if arsenic be present, the flame will be whitish.

If a piece of glass, china, or mica, being held in the flame, remains spotless, it is a sign that nothing but hydrogen is escaping; but if, on the contrary, the piece of glass, or china, or mica, being thus held in the flame, a deposit is formed thereon, of a white or brown colour, it is either metallic arsenic, or arsenious acid, or oxide of antimony; one or both.

To identify arsenic, the spirit-lamp J is to be lighted; whereupon the gas, in passing through the tube thus exposed to a red heat, will be decomposed, and the result will be that the metal of the arseniuretted hydrogen will be thereby reduced.

If the metal reduced by the heat is deposited in the tube, at a certain distance beyond the point at which the tube is heated, and if heat being applied again to that part where the deposit has taken place, this deposit, by being heated again volatilizes and goes beyond the place thus heated, to be deposited at another portion of the tube, and so on, then the compound contains *arsenic.*

This being ascertained, that part of the tube K drawn into a point may be broken, and the disengagement of gas may be left to take place, until the whole of the arsenic will have escaped in the shape of arseniuretted gas.

Caution.—When the compound contains arsenic, the disengagement of the arseniuretted hydrogen produced must never be suffered to take place in the apartment, but in the flue of the chimney, and great care is to be taken not to breathe any portion of it, as it is an exceedingly deleterious gas.

If *nitric acid* be present, it may be detected by adding gold leaf, which in that case will be dissolved.

Nitric acid may also be detected by protosulphate of iron in the following manner:—To the acid under examination add one-fourth of concentrated sulphuric acid, and the whole having become cold, drop into the liquid a crystal of protosulphate of iron; if nitric acid be present, that portion of liquid immediately in contact with the crystal of the salt of iron will assume a brownish-black colour.

The presence of free *chlorine* in hydrochloric acid may be detected by adding a few drops of solution of sulphate of indigo, which will then be decolorised. Free chlorine has a characteristic odour.

When hydrochloric acid contains sulphurous acid, the latter may be removed by adding a small quantity of peroxide of manganese in very fine powder, and agitating the whole; a certain quantity of chlorine is thus evolved, which transforms the sulphurous into sulphuric acid.

By careful distillation the hydrochloric acid passes over, leaving the sulphuric acid in the retort. If the small quantity of chlorine contained in the acid should prove objectionable, it may be removed by moderately heating the acid, or by putting aside the first portions which come over in distilling, as long as the solution of sulphate of indigo is decolorised.

The *perchloride of iron* may be eliminated by redistillation; it will remain in the retort.

If *arsenious* or *arsenic* acids be present, they may be removed by redistilling the acid with a small quantity of sulphuret of barium; three or four thousandths of the latter substance are generally sufficient to convert the arsenious or arsenic acids into sulphuret of arsenic, which remains in the retort; and this addition may be made immediately after that of the peroxide of manganase, as above described.

Arsenic and *arsenious* acids may also be completely separated by digesting the hydrochloric acid upon copper filings, decanting, and then distilling the acid.

HYDROCHLORATE OF AMMONIA. *See* SAL AMMONIAC.

HYPOCHLORITE OF LIME. *See* CHLORIDE OF LIME.

INDIGO.—Indigo is a blue colouring matter, which can be extracted from several tropical plants, but nearly all the indigo of commerce is the product of the various species of *Indigofera*. There are various modes of extracting indigo from the plant, and manufacturers differ in their opinion as to which is the best process of obtaining it.

Indigo should be in lumps of a fine deep purple colour, assuming a coppery hue when rubbed with a hard and polished body, such as the nail for example; and its fracture should be homogeneous, compact, fine-grained, and of a coppery colour. A dingy, dark, or brownish tinge, is a sign of adulteration or of bad quality. The lumps should be inodorous and light; if heavy, earthy impurities are present.

Good indigo should leave only a fine streak when rubbed upon a piece of white paper, this being one of the tests of the best quality, called *fine blue*. The other qualities are known as *ordinary blue, fine purple, purple and violet, dull blue, inferior purple aud violet, strong copper* and *ordinary copper*.

Besides these various shades or differences in the colour, the value of indigo may also be deduced in various ways. Thus, if indigo is too hard or brittle, the chests will contain a large proportion of small bits or powder; if the lumps exhibit crevices, or if the outer surface is blackish, or greenish; if, on breaking a lump, black spots are seen here and there; or if it looks blistered, and has little cavities, generally white internally (which is probably due to mouldiness); or if the lumps appear to consist of strata of various shades of colour, or be full of white spots; all these are imperfections or defects which affect the value of the drug in a serious manner. Indigo frequently contains sand, the presence of which may generally be detected by breaking a lump, and looking at the fracture whilst holding it horizontally between the eye and the light, in which case small shining points may be observed, which are the particles of sand. In general, when indigo is in hard dry lumps of a dark colour, it is considered of bad or of inferior quality. Indigo in dust, or in small bits, is often adulterated with sand, pulverised slate, and other earthy substances.

Estimation of the Value of Indigo.

(a.) *A Determination of Moisture.*—This is done by weighing off a certain quantity of indigo under examination—200 grains, for example—and exposing it (in a steam-bath) to a temperature of 212° Fahr., until it no longer diminishes in weight; the loss should not be more than from 3 to 6 per cent.

(b.) *Determination of Fixed Inorganic Matters.*—This is done by incinerating a given weight of the indigo—20 grains, for example—in a small platinum crucible or capsule. During this process the indigo, if of good quality, fuses and emits fumes of a fine purple colour. The quantity of ashes left is in general from 6 to 7 per cent., but the genuine indigo of Senegal leaves sometimes as much as 12 per cent. of ashes.

(c.) Introduce into a glass bottle, having a large mouth and provided with a glass stopper—

Indigo, dried at 212° Fahr. . . .	10·0	grains.
Crystallised protosulphate of iron (free from copper)	36·0	,,
Caustic potash	32·0	,,
Water	10,000·0	,,

The size of the bottle should be such that the above mixture will fill it completely; no air or empty space should be left, for otherwise the experiment may fail.

Stir the above mixture well, and after leaving it at rest for a quarter of an hour, plunge into it 80 grains of spun-wool, leaving them immersed therein for about five or ten minutes, according to the depth of colour which it may be desired to obtain.

The same process is repeated with indigo which is known to be of good quality or with indigotine, and the difference of colour indicates, of course comparatively, the value of the sample experimented upon.

This mode of estimating the value of indigo, however, shows only whether the drug is capable of producing a fine colour or not; but it does not indicate satisfactorily the quantity of available indigo which it contains, or, in other words, the extent of its tinctorial power. It is therefore better to leave the wool immersed into the liquor for about ten hours, and to replace it by a fresh quantity until the colouring matter is exhausted. The best indigo will of course dye the most stuff, and give the higher or deeper colour.

M. HOUTOU LABILLARDIÈRE determined the commercial value of indigo by means of an instrument to which he gave the name of colorimeter, and which consists of two perfectly cylindrical glass tubes (closed at one end) of about half an inch bore, and about thirteen or fourteen inches long. These two tubes must be made of the same glass, and of the same diameter and thickness. At about the $\frac{5}{6}$th part of their length from the closed end they are divided into two parts of equal capacity, the second half being graduated into 100 divisions. The two tubes are then placed into a small wooden box through two contiguous openings at the upper part of the box, and immediately behind which tubes two square holes or slits, corresponding to the diameter of the tubes, are cut, whilst the other end of the box, facing the tubes, has an eye-hole, so that by holding the box before the light, and looking at the tubes through the eye-hole, the difference of hue of the coloured liquor put into the tubes may be easily appreciated. The inside of the box should be blackened.

The operation is conducted thus:—Take a sample of each parcel of indigo to be examined, reduce the samples separately in fine powder, by triturating and sifting; weigh off 20 grains of each, and introduce that quantity (namely, 20 grains) into a small matrass perfectly clean and dry, pour upon it 400 grains of concentrated sulphuric acid of specific gravity 1·845, and leave the whole exposed to a gentle heat of about 100° or 110° Fahr. for about one hour, shaking the matrass from time to time, in order to promote the solution. When the indigo has dissolved, and the liquor has become cold, the whole is emptied into a large glass bottle capable of holding four pints of liquor, stirring the whole well with a glass rod; the matrass should be well rinsed with water, which is to be poured into the bottle, and more water is added until the bottle is completely filled up. Take now 10,000 grains-measure of this liquor, and pour them into another bottle, or glass beaker, which should be left at rest for a few hours, so that the liquor may settle well. The rest of the liquor, not being used, may be thrown away.

If several samples of indigo have to be tested, the operation just described must be repeated on 20 grains of each, so that they may all be examined at the same time and in the same manner.

The solution having settled, a portion of it is poured into the colorimeter tubes up to 0°; they are then introduced into the holes in the box, and their tint is examined by looking at them through the eye-hole opposite; if a difference in the depth of the colour is observed, water is added to that which has the deeper colour of the two; the aperture of the two being well closed with the finger, the liquid is well shaken and the tube is reintroduced back into its hole, water being again added, if need be, until the colour in the two tubes has acquired the same shade. By looking at the divisions on the tube to which water has been added, the operator knows at once the difference or relative colouring power of the two samples examined, for it is evident that that indigo is the richer or of more value which has required a greater quantity of water to be brought to the same pitch or intensity of colour as the other.

The value of indigo may also be tested in the following manner:—Take a portion of the indigo to be examined, reduce it to powder, and weigh off a certain quantity of it. Take also twice the weight of the indigo of quick-lime obtained by calcining oyster-shells or white marble; and for each 20 grains of indigo weighed off, take 10,000 grains-measure of water; with part of that water slake the lime, and with another portion of it grind the indigo into impalpable powder with a muller on a slab. The hydrate of lime (slaked-lime) is then mixed with the indigo, and the mixture is ground again with the muller as perfectly as possible. The triturated mass is then introduced into a large flask capable of holding the whole, taking care, of course, not to spill or waste anything; the slab and the muller are washed with some of the measured water which is also poured into the flask, and it is then filled up with the remainder of the water.

If the same flask is always used, and its capacity is known, the operator may of course dispense with measuring the water.

The flask containing the mixture should be exposed for several hours at a temperature of from 176° to 194° Fahr. by keeping it plunged in a water-bath heated to that point. In consequence of this treatment the lime combines with the brown of indigo, and the colouring matter is set free. A little protosulphate of iron (free from copper), finely pulverized, must be dissolved in the liquor. The quantity of protosulphate of iron should be about two-thirds of the lime employed. As soon as this is done, the flask must be closed and well stirred, and it is again placed in the water-bath, and allowed gradually to cool there. The mixture gradually becomes green; when it has cooled, the clear liquor should be siphoned out from the sediment into a graduated vessel, up to a certain point. The colouring matter becomes oxidized by the air, and in order to promote this oxidation, and to keep the lime and other foreign bodies in solution, a little hydrochloric acid should be added to the decanted liquor. When it has cleared it is poured on a weighed filter, and the precipitate thus separated, and which is pure indigo, being washed and dried at 212° Fahr., is then weighed.

Suppose, for example, that the quantity of indigo operated upon is 100 grains, which will have required 500 divisions (50,000 grains-measure) of water, and that 200 divisions (20,000 grains-measure) having ultimately been left to oxidize, have yielded 15 grains of indigo, the indigo under examination contained 37½ per cent. of pure indigo.

$$200 : 15 :: 500 : x = 37{\cdot}5.$$

M. Dana proposed another method ('Journal of Prac. Chem.,' xxvi. p. 398), which consists in boiling the indigo with carbonate of sodium, adding protochloride of tin from time to time, and precipitating the clear solution by one of bichromate of potassium; filtering, washing the precipitate with dilute hydrochloric acid in order to remove the hydrate of oxide of chromium, drying, and then weighing the indigo, which should then be incinerated; and the ashes being deducted from the weight thus obtained, gives the proportion of pure indigo.

Fritsche's Process.—If indigo be treated with a solution of caustic potash in spirits of wine, a small quantity of peculiar indigo blue is obtained in the form of scales. The process is based on the reduction of indigo, for which purpose spirit of wine is used instead of water, as in the ordinary process; and in lieu of the substances employed in other cases for effecting this reduction, grape-sugar is substituted on account of its solubility in alcohol; for the same reason lime is replaced by caustic potash, or caustic soda.

One part of indigo, with one part of grape-sugar, are put into a bottle capable of containing 40 parts of liquor. The bottle is half filled with boiling alcohol, and the other half with alcohol previously mixed with 1½ parts of very concentrated ley of caustic soda. The bottle being thus charged is strongly agitated, and then left at rest for some time. After the liquid has become bright, it is drawn into another bottle by means of a siphon. The liquor thus obtained, whilst protected from the contact of the air, is of a yellowish-red colour, and so dark that it appears transparent only when in thin layers. As soon, however, as it is exposed to the influence of the oxygen of the air it becomes purple, and quickly passes through the different tinges of red, violet, and blue, whilst the whole of the indigo blue is deposited in the form of scales. This is obtained as a very fine, light, crystalline powder; whilst all the other substances contained in commercial indigo either remain undissolved at the commencement, or remain in solution whilst the blue colouring matter is depositing. After the indigo blue has been placed on a filter and washed with a little alcohol, it must be washed with water, and this is easily and speedily effected. On the crystals minute globules of a substance insoluble in alcohol are commonly deposited, which, however, easily dissolve in water, and are produced by the action of caustic soda on the grape-sugar.

Commercial indigo seldom contains 50 per cent. of blue colouring matter; the remainder consists of either accidental or of intentional impurities. In general it may be said that the lighter the specific gravity of the lumps of indigo, the better the drug.

IODIDE OF POTASSIUM (Hydriodate of Potash).—Iodide of potassium is employed for medicinal purposes, and is extensively used in photography.

Iodide of potassium is white and opaque; it has a pungent taste, and it emits purple fumes when treated, with the help of heat, by either nitric or by sulphuric acid; it crystallizes in cubes. 100 parts of water at 64° Fahr. dissolve 143 parts of iodide of potassium.

Commercial iodide of potassium is sometimes contaminated by *chloride of potassium* or other *chlorides;* occasionally it contains also some *potash* or *carbonate of potassium*, and likewise *iodate of potassium*, especially when manufactured on a large scale.

Pure iodide of potassium should entirely dissolve in water and in alcohol; it should have no action, or only in a very trifling degree, upon litmus- or turmeric-paper; it should not lose weight by ignition; if it does, the loss is probably water.

Iodide of potassium gives, with excess of tartaric acid, a white granular precipitate; with nitrate of silver, a yellowish one, which is insoluble in dilute nitric acid, and almost insoluble in ammonia, turning, however, white; and a vermilion red precipitate with bichloride of mercury soluble in excess of the solution or the reagent; it gives a violet blue colour with a little mucilage of starch upon subsequent addition of a few drops of chlorine water, by which it is distinguished from bromide and chloride of potassium.

Impurities and Adulterations.—Dissolve about a drachm of the salt in about a fluid drachm of water, and add 1½ oz. of strong alcohol. The solution should remain clear; a turbidity indicates foreign salts, e.g. *carbonate*, *sulphate*, *iodate*, *nitrate*. Should a notable precipitate take place, collect it on a filter, wash with alcohol, redissolve in a few drops of hot water, and test with *turmeric-* or *red litmus-paper*. If the tumeric-paper become brown and the red litmus-paper blue, a carbonate is present; acidulate the rest of the solution with hydrochloric acid, and test for *sulphate* by the addition of a drop of chloride of barium, and for *nitrate* by tinging it faintly with sulphuric acid and indigo solution, and heating. *Iodate of Potassium* is detected in an aqueous solution of the salt by adding a few drops of mucilage of starch, and then a few drops of concentrated solution of tartaric acid insufficient to cause a precipitate; if *iodate* be contained in the salt, a violet colouration of the liquid will occur at once; or the aqueous solution mixed with a few drops of concentrated solution of tartaric acid may be shaken with some chloroform, which will assume a *red* colour when iodate is present.

Chloride and *bromide* are detected by carefully precipitating a warm diluted aqueous solution of the salt with nitrate of silver; a slight excess of ammonia is then added, and after agitation, the mixture filtered, and the filtrate supersaturated with nitric acid. Since ammonia dissolves only a trace of iodide of silver, the transparency of the liquid must not be at all, or only slightly impaired; a white precipitate indicates bromide or chloride. In order to distinguish these the precipitate is collected on a filter and washed with a little water until this ceases to redden-blue litmus-paper; the filter is then pierced by a glass rod and the precipitate rinsed into a test-tube; after subsidence the water is, as far as possible, decanted, and chlorine water added and agitated with the precipitate. Since chlorine decomposes bromide of silver, dissolving the disengaged bromine with a yellow colour, bromine will be recognised by a more or less deep colouring of the fluid, while chloride of silver remains unchanged and without any action on chlorine water. When chloroform or ether is then added to the fluid and agitated, it will absorb the bromine and the yellow colour from the water.

A quantitave estimation of the purity of iodide of potassium may be made by completely precipitating with nitrate of silver a warm solution of 10 grains of the salt in about one ounce of water. After cooling and subsidence the supernatant liquid is carefully decanted; one fluid drachm of pure ammonia, diluted with two drachms of water, is then added to the precipitate, and after agitation for a few minutes the latter is collected upon a tared, moist filter, is washed with a little water, and dried at a temperature not exceeding 80° C. If the iodide of potassium was pure, 14·1 grains of silver salt should be obtained.

IODINE.—Iodine is a simple body, solid at the ordinary temperature, of a bluish-black colour and metallic lustre, like black lead; it is often met with in flakes or in plates. It is soft and friable to the touch, its taste is very acrid, and its odour resembles that of chlorine. When touched, it leaves a brown stain on the skin, but the stain disappears by evaporation. Its structure is lamellated; its specific gravity is 4·946.

Iodine is sometimes adulterated with *graphite* (black-lead, plumbago), *peroxide of manganese*, *crude antimony*, *micaceous iron ore*, with *coals*, &c. As, however, iodine is entirely soluble in alcohol, these sophistications are very easily detected. Iodine, besides being entirely volatilizable by heat in fine purple fumes, readily condensible, may be thus easily separated by sublimation, at about 356° Fahr., and directly weighed, separately from the fraudulent additions.

If dissolved in alcohol, the iodine may be readily recovered, simply by pouring into the alcoholic solution a sufficient quantity of water, which precipitates it in the form of a brown powder, which may be collected on a filter, carefully dried, and weighed.

The iodine met with in commerce is generally adulterated by variable proportions of water, sometimes to the extent of 15 or 18 per cent. This impurity may be detected by pressing it gently between two folds of blotting-paper, and then putting it under a glass bell, in a shallow basin or capsule, by the side of or above a dish containing caustic lime or concentrated sulphuric acid, by which the moisture is absorbed. When the weight diminishes no longer, the loss indicates the amount of water.

Assay of Commercial Iodine (MOHR's method, modified by M. A. ROBIERRE).—Make a concentrated solution of iodide of potassium; this is to dissove the iodine which is to be tested. A standard solution of *arsenite of sodium* is obtained by dissolving 4·95 grammes of arsenious acid with 14·5 grammes of crystallised carbonate of sodium, and diluting the aqueous liquid to 1 litre. This solution should decolorize an iodized liquid containing 12·688 grammes of iodine per litre. But supposing that the arsenious acid may not have this reducing power, the test will be none the less exact, as at the time of performing it the relation of a given weight of pure iodine to the arsenite will also be determined. A somewhat concentrated solution of bicarbonate of sodium is also to be prepared.

The analysis is best effected in a small stoppered flask. Into this are put 10 c.c. of the arsenite of sodium, to which must be added 5 c.c. of bicarbonate of sodium; the whole then receives a further addition of about 4 c.c. of perfectly colourless benzol. Weigh a certain quantity of pure iodine between two watch-glasses; dissolve this in the concentrated solution of iodide of potassium prepared beforehand, and which must be of the same strength in all the various estimations which may be made; with this coloured solution fill a flask containing 100 c.c., shake it, and pour the contents into a graduated burette. On allowing the iodized solution to fall into the arsenite drop by drop, and stirring it quickly, the brown colour will be seen to disappear instantaneously; but scarcely will all the arsenite have been changed to arseniate when the solution of iodine will produce a double reaction: in the first place, the benzol will turn red; secondly, the aqueous liquid, which was perfectly colourless at the beginning of the operation, assumes a very sensible yellowish tinge—the significant character of this is the more surprising when we remember the very small quantity of iodine which causes it.

A second experiment is now to be performed upon the iodine to be estimated; and the same weight being used, its standard is at once shown, since the volume of the solution requisite to destroy the alkaline arsenite is in inverse proportion to the quantity of real iodine to be determined.

IRON (Analysis of Iron Ores).—Iron ore is the name given to any substance containing enough iron to repay the expense of extracting it; and as even small proportions of *phosphorus*, or of *sulphur*, or of *arsenic*, are exceedingly prejudicial to the quality of iron, the toughness of which they either impair or destroy, the ores containing any of these substances in quantity are rejected.

The ores of iron most generally employed are the *magnetic oxide of iron, anhydrous peroxide of iron, hydrate of peroxide of iron, carbonate of protoxide of iron* (black band), *argilaceous carbonate of iron* (clay iron-stone).

Dry Assay of Iron Ores.—The object of the dry assay of an iron ore is to ascertain, by an experiment on a small scale, the amount of iron which the ore should yield when smelted on the large scale in the blast-furnace. For this purpose the metal must be deoxidized, and such a temperature produced as to melt the metal and the earths associated with it in the ore, so that the former may be obtained as a dense button at the bottom of the crucible, and the latter in a lighter glass or slag above it. Such a temperature can only be obtained in a wind-furnace, connected with a chimney at least thirty feet high; and when made expressly for assaying, the furnace is generally built of such a size that four assays may be made at the same time, namely, about fourteen inches square and two feet in depth from the under side of the cover to the movable bars of iron which form the grate. In order that the substances associated with the iron in the ore should form a fusible compound, it is usually requisite to add a flux, the nature of which will depend on the character of the ore under examination. BERTHIER divides iron ores into five classes:—

1. The almost pure oxides, such as the *magnetic oxide*, *ologistic iron*, and the *hæmatites.* 2. Ores containing *silica*, but free, or nearly so, from any other admixture. 3. Ores containing *silica* and various bases, such as *lime*, *magnesia*, *alumina*, *oxide of manganese*, *oxide of titanium*, *oxide of tantalum*, *oxide of chromium*, or *oxide of tungsten*, but little or no *silica.* 4. Ores containing *silica*, *lime*, and *another base*, and which are fusible alone. Ores of the first class may be reduced without any flux; but it is always better to employ one, as it greatly facilitates the formation of the button: borax may be used, or, better, a fusible earthy silicate, such as ordinary flint-glass. Ores of the second class require some base to serve as a flux, such as carbonate of sodium, or a mixture of carbonate of calcium and clay, or of carbonate of calcium and dolomite. Ores of the third class are mixed with carbonate of calcium in the proportion of from one-half to three-fourths of the weight of the foreign matter present in the ore. Ores of the fourth class require as a flux silica in the form of rounded quartz, and generally also some lime. The manganesian spathic ores, which belong to this class, may be assayed with the addition of silica alone, but the magnesian spathic ores require lime. Ores of the fifth class require no flux.

Method of Conducting the Assay.—One hundred grains of the ore, finely pulverized and passed through a silk sieve, are well mixed with the flux, and the mixture introduced into the smooth cavity made in the centre of a crucible that has been lined with charcoal. The lining of the crucible is effected by partially filling it with coarsely powdered and slightly damped charcoal, which is then rammed into a solid form by the use of a light wooden pestle. The mingled ore and flux must be covered with charcoal. The crucible, thus filled, is closed with an earthen lid luted on with fire-clay, and is then set on its base in the air-furnace. The heat should be very slowly raised, the damper remaining closed during the first half hour. In this way the water of the damp charcoal exhales slowly, and the deoxidation of the ore is completed before the fusion begins; if the heat were too high at first, the luting would probably split, and moreover the slag formed would dissolve some oxide of iron, which would of course be lost to the button, and thus give an erroneous result. After half an hour the damper is gradually opened, and, the furnace being filled with fresh coke, the temperature is raised progressively to a white heat, at which pitch it must be maintained for a quarter of an hour; the damper is then closed, and the furnace allowed to cool. As soon as the temperature is sufficiently reduced, the crucible is removed, and opened over a sheet of brown paper; the *brasque* is carefully removed, and the button of cast iron taken out and weighed. If the experiment has been entirely successful, the iron will be found at the bottom of the crucible in a small rounded button, and the slag will be entirely free from any adhering metallic globules, and will resemble in appearance green bottle-glass; should, however, the slag contain small metallic particles, the experiment is not necessarily a failure, as they may generally be recovered by washing, and the magnet; but if, on breaking the crucible, the reduced metal should be found in a partially melted state, and not collected into a distinct mass, it indicates either too low a temperature or an improper selection of fluxes, and the experiment must be repeated. The iron obtained is not chemically pure; it contains *carbon*, and, if the ore be manganiferous, *manganese*: the result is therefore somewhat too high, though indicating with sufficient exactness, for all manufacturing purposes, the richness of the ore assayed.

Humid Assay of Iron Ores.—Too great care cannot be bestowed on the *sampling* of ores intended for analysis. To expend so much time and labour on an isolated specimen (unless for a special object) is worse than useless. The sample operated upon should be selected from a large heap, which should be thoroughly gone over, and several pieces taken from different parts; these should be coarsely powdered and mixed, and about half a pound taken from the mass should be preserved in a well-stoppered bottle for the analysis.

(1.) *Determination of Water* (*hygroscopic and combined*).—About 50 grains of the ore are dried in the water-oven, till no further loss of weight takes place; the loss indicates hygroscopic water; the residue is introduced into a tube of hard glass, to which is adapted a weighed tube containing chloride of calcium; the powder is then gradually raised to a low red-heat, the combined water is thereby expelled, and its amount determined by the increase in weight of the chloride of calcium tube. Some ores (the hydrated hæmatites) contain as much as 12 per cent. of combined water.

(2.) *Sulphuric Acid and Sulphur.*—From 30 to 50 grains of the ore are digested with hydrochloric acid, filtered, and washed. The filtrate—concentrated, if necessary, by evaporation—is precipitated by excess of chloride of barium. The insoluble residue on the filter is fused in a platinum or gold crucible with nitre and carbonate of sodium; the fused mass is dissolved in hydrochloric acid, evaporated to dryness, redissolved in dilute hydrochloric acid, filtered, and precipitated as before by chloride of barium; every 100 parts of the sulphate of barium produced indicate 13·734 parts of sulphur, corresponding with 25·48 parts of pyrites. In the analysis of hæmatites, it is necessary to bear in mind that perchloride of iron is partially reduced when boiled with finely divided iron pyrites and hydrochloric acid, sulphuric acid being formed. (Dick.)

(3.) *Phosphoric Acid.*—From 50 to 75 grains of the ore are digested with hydrochloric acid, and filtered. The clear solution, which should not be too acid, is boiled with sulphite of ammonium, added gradually in small quantities, till it either becomes colourless or acquires a pale green colour, indicating that the peroxide of iron originally present has been reduced to protoxide. The solution is nearly neutralized with carbonate of ammonium, excess of acetate of ammonium added, and the liquid boiled; strong solution of perchloride of iron is then added, drop by drop, until the precipitate which forms has a distinct red colour: this precipitate, which contains all the phosphoric acid originally present in the ore, is collected on a filter, washed, and redissolved in hydrochloric acid, tartaric acid added, and then ammonia. From this ammoniacal solution the phosphoric acid is finally precipitated as ammonio-magnesian phosphate, by the addition of chloride of ammonium, sulphate of magnesium, and ammonia. The precipitate is allowed twenty-four hours to subside; it is then collected on a filter; and if it has a yellow colour, which is almost invariably the case, it is redissolved in hydrochloric acid, and more tartaric acid being added, it is again precipitated by ammonia. 100 parts of the ignited pyrophosphate of magnesium correspond to 64·3 parts of phosphoric acid.

(4.) *Determination of the remaining Constituents.*—25 or 30 grains of the finely-powdered ore are digested for about half an hour with strong hydrochloric acid, diluted with boiling distilled water, and filtered. The residue on the filter being thoroughly washed, the solution is peroxidized, if necessary, by the addition of chlorate of potassium, nearly neutralized by ammonia, boiled with excess of acetate of ammonium, and rapidly filtered while hot; the filtrate (which should be colourless), together with the washings, is received in a flask, ammonia is added, and then a few drops of bromine, and the flask closed with a cork. In a few minutes, if manganese be present, the liquid acquires a dark colour; it is allowed to remain at rest for twenty-four hours, then warmed, and rapidly filtered and washed; the brown substance on the filter is hydrated peroxide of manganese: it loses its water by ignition, and then becomes $Mn_3 O_4$, 100 parts of which correspond to 92·14 parts of protoxide.

The liquid filtered from the manganese contains the *lime* and *magnesia*; the former is precipitated by oxalate of ammonium, and the oxalate of calcium formed converted by ignition into carbonate, in which state it is either weighed (having been previously evaporated with carbonate of ammonium), or it is converted into sulphate by the addition of a few drops of sulphuric acid, evaporation, and ignition. The lime being separated, the magnesia is thrown down as ammonio-magnesian phosphate by phosphate of sodium and ammonia; and after standing for twenty-four hours it is collected on a filter, washed with cold ammonia-water, dried, ignited, and weighed. 100 parts of carbonate of calcium correspond to 56·0 of lime, 100 parts of sulphate of calcium to 40·1 of lime, and 100 parts of pyrophosphate of magnesium to 36·22 of magnesia.

The red precipitate collected on the filter after the boiling with acetate of ammonium consists of the basic acetate of *iron*, and perhaps of aluminium, together with the *phosphoric acid*. It is dissolved in a small quantity of hydrochloric acid, and then boiled in a silver or platinum basin with considerable excess of pure caustic potassa; the alumina (with the phosphoric acid) is hereby dissolved, the insoluble portion is allowed to subside, and the clear liquid is then decanted, after which the residue is thrown on a filter and washed; the filtrate and washings are supersaturated with hydrochloric acid, nearly neutralized with ammonia, and the alumina finally precipitated by carbonate of ammonium. From the weight of the ignited precipitate the corresponding amount of phosphoric acid, determined by a separate operation, is to be deducted; the remainder is calculated as *alumina*. The residue left after digesting the ore with hydrochloric acid consists principally of *silica*, but it may also contain *alumina*, *peroxide of iron*, *lime*, *magnesia*, and *potassa*. For practical purposes, it is rarely necessary to submit it to minute examination; should such be desired, it must be dried, ignited, and weighed, then fused in a platinum crucible with four times its weight of mixed alkaline carbonates, the fused mass dissolved in dilute hydrochloric acid, and evaporated to dryness, the residue moistened with strong hydrochloric acid; and after standing at rest for some hours, digested with hot water, filtered, and the *silica* on the filter ignited and weighed. The *alumina*, *lime*, *oxide of iron*, and *magnesia* in the filtrate, are separated from each other according to the instructions given above; the *potassa* is estimated by a distinct process.

(5.) *Carbonic Acid.*—This acid, which constitutes a considerable part of the weight of that large and important class of ores, the *clay ironstones*, is estimated by noting the loss sustained after adding to a weighed portion of the ore sulphuric acid, and thus evolving the gas; or more roughly, by the loss sustained in the entire analysis. Another method is to fuse 20 or 25 grains of the ore with 60 or 80 grains of dry borax, and noting the loss, which consists of water and carbonic acid; by deducting the water obtained in a previous experiment, the quantity of carbonic acid is obtained. This method, however, can scarcely be recommended on account of the corrosion of the crucible, though the results are very accurate.

(6.) *Determination of the Iron.*—This is performed on a separate portion of the ore, either by the volumetric method of MARGUERITE, or by that of Dr. PENNY. Both give very exact results.

(a.) *Marguerite's Method.*—This is based on the reciprocal action of the salts of protoxide of iron and permanganate of potassium, whereby a quantity of the latter is decomposed exactly proportionate to the quantity of iron. The ore (about 10 or 15 grains) is dissolved in hydrochloric acid, and the metal brought to the minimum of oxidation by boiling the solution with *sulphite of sodium* (or better, by pure metallic zinc); the solution of permanganate of potassium is then cautiously added drop by drop, until the pink colour appears, and the number of divisions of the burette required for the purpose accurately noted. The solution should be considerably diluted, and there must be a sufficient quantity of free acid present to keep in solution the peroxide of iron formed, and also the oxide of manganese. The whole of the iron must be at the *minimum* of oxidation, and the excess of sulphurous acid must be completely expelled: if the latter precaution be neglected an erroneous result will be obtained, as the sulphurous acid will itself take oxygen from the permanganic acid, and thus react in the same manner as iron.

To prepare the permanganate of potassium, 7 parts of chlorate of potassium, 10 parts of hydrate of potassa, and 8 parts of peroxide of manganese, are intimately mixed. The manganese must be in the finest possible powder, and the potassa having been dissolved in water, is mixed with the other substances, dried, and the whole heated to very dull redness for an hour. The fused mass is digested with water, so as to obtain as concentrated a solution as possible, and dilute nitric acid added till the colour becomes violet; it is afterwards filtered through asbestos. The solution must be defended from the contact of organic matter, and kept in a glass-stoppered bottle. If the solution be evaporated, it yields beautiful red acicular crystals. It is better to employ the crystals in the preparation of the test-liquor, as the solution keeps much better when no *manganate* is present. To prepare the normal or test-liquor, a certain quantity, say 5 grains, of pianoforte wire are dissolved in pure hydrochloric acid; after the disengagement of hydrogen has ceased, and the solution is complete, the liquor is diluted with about a pint of water, and accurately divided by measurement into two equal parts, the number of burette divisions of the solution of permanganate required to produce in each the pink colour is accurately noted, and this number is then employed to reduce into weight the result of the analysis of an ore. A useful normal liquor is made by dissolving 100 grains of the crystals in 10,000 grains of water.

(b.) *Penny's Method.*—This is based on the reciprocal action of chromic acid and protoxide of iron, whereby a transference of oxygen takes place, the protoxide of iron becoming converted into peroxide, and the chromic acid into sesquioxide of chromium. The process is conducted as follows:—A convenient quantity of the specimen is reduced to coarse powder, and one-half at least of this is still further pulverized until it is no longer gritty between the fingers. The test-solution of bichromate of potassium is next prepared; 444 grains of this salt, in fine powder, are weighed out, and put into a burette graduated into 100 equal parts; warm distilled water is afterwards poured in until the instrument is filled to 0. The palm of the hand is then securely placed on the top, and the contents agitated, by repeatedly inverting the instrument, until the salt is dissolved, and the solution rendered of uniform density throughout. Each division of the solution thus prepared contains 0·444 grain of bichromate, which Dr. PENNY ascertained to correspond to half a grain of metallic iron. The bichromate must be pure, and should be thoroughly dried by being heated to incipient fusion. 100 grains of the pulverized ironstone are now introduced into a Florence flask, with 1½ oz. by measure of strong hydrochloric acid and ½ oz. of water: heat is cautiously applied, and the mixture occasionally agitated, until all effervescence caused by the escape of carbonic acid ceases; the heat is then increased, and the mixture made to boil, and kept at a moderate ebullition for ten minutes or a quarter of an hour; about 6 oz. of water are next added, and mixed with the contents of the flask, and the whole filtered into an evaporating-basin. The flask is rinsed several times with water, to remove all adhering solution, and the residue on the filter is well washed. Several small portions of a weak solution of *red ferricyanide of potassium* (containing 1 part of salt to 40 of water) are now dropped upon a white porcelain slab, which is conveniently placed for testing the solution in a basin during the next operation. The prepared solution of bichromate of potassium in the burette is then added very cautiously to the solution of iron, which must be repeatedly stirred, and as soon as it assumes a dark greenish shade it should be occasionally tested with the ferricyanide: this may easily be done by taking out a small quantity on the end of a glass rod and mixing it with a drop of the solution on the porcelain slab. When it is noticed that the last drop communicates a distinct *blue* tinge, the operation is terminated; the burette is allowed to drain for a few minutes, and the number of divisions of the test liquor consumed read off. This number multiplied by two gives the amount of iron per cent. The necessary calculation for ascertaining the corresponding quantity of protoxide is obvious. If the specimen should contain iron in the form of peroxide, the hydrochloric solution is deoxidized by sulphite of ammonium. The presence of peroxide of iron in an ore is easily detected by dissolving 30 or 40 grains in hydrochloric acid, diluting with water, and testing a portion of the solution with *sulpho-cyanide of potassium.* If a decided blood-red colour is produced, peroxide of iron is present. If it be desired to ascertain the relative proportions of peroxide and protoxide in an ore, two operations must be performed, one on a quantity of ore that has been dissolved in hydrochloric acid in a stout closed bottle, or in a flask through which a current of carbonic acid gas is maintained, and another on a second quantity that has been dissolved as usual and then deoxidized by sulphite of ammonium or by pure metallic zinc. It is advisable to employ the solution of bichromate much weaker than that proposed by PENNY, and to employ a burette graduated to cubic millimètres—a good strength is 1 grain of metallic iron = 10 cubic centimètres of bichromate.

Metals Precipitable by Sulphuretted Hydrogen from the Hydrochloric Solution.—A weighed portion of the ore, varying from 500 to 2,000 grains, is digested for a considerable time in hydrochloric acid: the solution is filtered off; the iron in the filtrate reduced when necessary by sulphite of ammonium, and a current of sulphuretted hydrogen passed through it. The small quantity of sulphur (which is always suspended) is collected on a filter and thoroughly washed; it is then incinerated at as low a temperature as possible. The residue (if any) is mixed with carbonate of sodium and heated upon charcoal before the blowpipe; any globules of metal that may be obtained are dissolved and tested.

Analysis of Pig-Iron.—The most important constituents to be determined are *carbon* (combined and uncombined), *silicon*, *sulphur*, *phosphorus*; those of less consequence, or of more rare occurrence, are *manganese*, *arsenic*, *copper*, *zinc*, *chromium*, *titanium*, *cobalt*, *nickel*, *tin*, *aluminum*, *calcium*, *magnesium*, and the *metals of the alkalies.*

(1.) *Determination of the total Amount of Carbon.*—About 100 grains of the iron in small pieces are digested, at a moderate temperature, in 6-oz. measures of a solution formed by dissolving 6 oz. of crystallized sulphate of copper, and 4 oz. of common salt in 20 oz. of water and 2 oz. of concentrated hydrochloric acid. The action is allowed to proceed until all, or nearly all, the iron is dissolved. *Carbon and copper* are left insoluble; these are collected on a filter, and washed first with dilute hydrochloric acid (to prevent the precipitation of subchloride of copper), then with water, then with dilute caustic potassa, and finally with boiling water. The mixed carbon and copper are dried on the filter, from which they are easily removed by a knife-blade, and are mixed with oxide of copper, and burnt in a combustion-tube in the usual way, with a current of air or, still better, of oxygen. The carbonic acid is collected in Liebig's apparatus, and from its weight the amount of carbonic is calculated.

(2.) *Graphite,* or *Uncombined Carbon.*—A weighed portion of the finely divided iron (filings or borings may be used) is digested with moderately strong hydrochloric acid; the combined carbon is evolved in combination with hydrogen, while the graphite is left undissolved. It is collected on a filter, washed, and then boiled with a solution of caustic potassa, sp. gr. 1·27, in a silver dish; the silica which existed in the form of silicon is hereby dissolved; the clear caustic solution drawn off by a pipe or siphon, and the black residue repeatedly washed; it is dried at as high a temperature as it will bear, and weighed; it is then heated to redness in a current of air, until the whole of the carbon is burnt off. A reddish residue generally remains, which is weighed, and the weight deducted from that of the original black residue; the difference gives the amount of graphite. This residue frequently contains *titanic acid.*

(3.) *Silicon.*—The amount of this element is determined by evaporating to dryness a hydrochloric solution of a weighed quantity of the metal: the dry residue is re-digested with hydrochloric acid, diluted with water, boiled and filtered; the insoluble matter on the filter is washed, dried, and ignited, until the whole of the carbon is burnt off; it is then weighed, after which it is digested with solution of potassa, and the residue, if any, washed, dried, ignited, and weighed: the difference between the two weights gives the amount of silicic acid, 100 parts of which indicate 47 parts of *silicon.*

(4.) *Phosphorus.*—A weighed portion of the metal is digested in nitro-hydrochloric acid, evaporated to dryness, and the residue redigested with hydrochloric acid. The solution is treated precisely as recommended for the determination of phosphoric acid in ores; every 100 parts of pyrophosphate of magnesia indicate 28·5 parts of phosphorus.

(5.) *Sulphur.*—In *grey* iron this element is very conveniently and accurately estimated by allowing the gas evolved by the action of hydrochloric acid on a weighed quantity (about 100 grains) of the metal, in filings or borings, to pass slowly through a solution of acetate of lead acidified by acetic acid: the sulphur—the whole of which takes the form of sulphuretted hydrogen—enters into combination with the lead, forming a black precipitate of sulphide of lead, which is collected, washed, and converted into sulphate of lead, by digesting it with nitric acid, evaporating to dryness, and gently igniting. 100 parts sulphate of lead = 10·55 sulphur. The most minute quantity of sulphur in iron is detected by this process. If, however, crude *white* iron is under examination, this method does not give satisfactory results, on account of the difficulty with which it is acted upon by hydrochloric acid; it is better, therefore, to treat the metal with nitro-hydrochloric acid, evaporate to dryness, redigest with hydrochloric acid, and then precipitate the filtered solution with excess of chloride of barium; or the finely divided metal may be fused in a gold crucible with an equal weight of pure nitrate of sodium and twice its weight of pure alkaline carbonates; the fused mass is extracted with water acidified with hydrochloric acid, and finally precipitated by chloride of barium. M. Nickels ('Jour. de Pharm. et de Chimie') suggests the use of pure *bromine* mixed with distilled water as a solvent for cast iron or steel.

(6.) *Manganese.*—This metal is determined by the process described for its estimation in iron ores; the iron must exist in the solution in the form of sesquioxide.

(7.) *Arsenic and Copper.*—The nitro-hydrochloric solution of the metal is evaporated to dryness, redigested with hydrochloric acid, and filtered. The iron in the clear solution is reduced to protochloride by boiling with a sufficient quantity of sulphite of ammonium; the solution is boiled till it has lost all smell of sulphurous acid. It is then saturated with sulphuretted hydrogen, and allowed to stand for twenty-four hours in a closed vessel, the excess of gas is boiled off, and the precipitate, if any, collected on a small filter and well washed; it is digested with monosulphide of potassium, which dissolves the sulphide of arsenic, leaving the sulphide of copper untouched; the latter is decomposed by heating with nitric acid, and the presence of copper evinced by the addition of ammonia, which produces a fine blue colour; the sulphide of arsenic is precipitated from its solution in sulphide of potassium by dilute sulphuric acid; it may be redissolved in aqua-regia, and the nitric acid having been expelled by evaporation, the arsenic may be reduced in MARSH'S apparatus.

(8.) *Nickel and Cobalt.*—These metals, if present, will be found in the solution from which the copper and arsenic have been precipitated by sulphuretted hydrogen. The solution is peroxidized, and the sesquioxide of iron precipitated by slight excess of carbonate of barium, after which the nickel and cobalt are precipitated by sulphide of ammonium.

(9.) *Chromium and Vanadium.*—These metals, which should be looked for in the carbonaceous residue obtained by dissolving a large quantity of the iron in dilute hydrochloric or sulphuric acid, are detected as follows (WÖHLER):—The ignited residue is intimately mixed with one-third of its weight of nitre, and exposed for an hour in a crucible to a gentle ignition. When cool, the mass is powdered and boiled with water. The filtered solution is gradually mixed and well stirred with nitric acid, taking care that it may still remain slightly alkaline, and that no nitrous acid is liberated which would reduce the vanadic and chromic acids. The solution is then mixed with an excess of solution of chloride of barium as long as any precipitate is produced. The precipitate, which consists of vanadate and chromate of baryta, is decomposed with slight excess of dilute sulphuric acid, and filtered. The filtrate is neutralised with ammonia, concentrated by evaporation, and a fragment of chloride of ammonium placed in it. In proportion as the solution becomes saturated with chloride of ammonium, *vanadate* of ammonium is deposited as a white or yellow crystalline powder. To test for chromium only, the mass after fusion with nitre is extracted with water, and then boiled with carbonate of ammonium; the solution is neutralized with acetic acid, and then acetate of lead added: the production of a yellow precipitate indicates *chromic* acid.

(10.) *Aluminum.*—This metal is best separated from iron by first reducing the latter to the state of protoxide by sulphite of ammonium, then neutralizing with carbonate of sodium, and afterwards boiling with excess of caustic potassa until the precipitate is black and pulverulent. The solution is then filtered off, slightly acidulated with hydrochloric acid, and the alumina precipitated by sulphide of ammonium.

(11.) *Calcium and Magnesium.*—These metals are found in the solution from which the iron and aluminum have been separated; they both exist probably (together with the aluminum) in the cast-iron in the form of *slag*, and are best detected in the black residue which is left on dissolving the iron in dilute sulphuric or hydrochloric acid. After digesting this residue with caustic potassa, and burning away the graphite, a small quantity of red powder is left, which is composed of silicic acid, oxide of iron, alumina, lime, magnesia, and perhaps titanic acid; if 500 grains of cast-iron are operated upon, a sufficient quantity of insoluble residue will be obtained for a quantitative determination of its constituents. Moderately strong acid should be used, and no heat applied; it should be allowed to act on the iron for about a week, being repeatedly agitated.

(12.) *Determination of Carbon in Cast-Iron and Steel.*—About 100 grains of the steel in small pieces are digested in 6-oz. measures of a solution of chloride of copper made by mixing 6 oz. of crystallized sulphate of copper, and 4 oz. of chloride of sodium with 20 oz. of water, and 2 oz. of concentrated hydrochloric acid. The mixture is warmed only, not heated so as to evolve hydrogen. The action is allowed to proceed until all, or nearly all, of the steel is dissolved. The residue, consisting of carbon and metallic copper, is collected on a filter and washed with dilute hydrochloric acid to prevent the precipitation of subchloride of copper, then with water, then with dilute caustic potassa, to ensure the removal of all the acid, and finally with water; it is then dried. The carbon and copper are easily removed from the filter by the blade of a knife; they are mixed with oxide of copper, and burnt in a combustion-furnace with a current of air purified from carbonic acid by passing through a solution of caustic potassa; the carbonic acid is collected as usual in LIEBIG's bulbs after drying by chloride of calcium. If *graphite* be present, it will be necessary to burn the carbon in a current of oxygen gas.

ISINGLASS.—Isinglass is a glue, manufactured almost exclusively in Russia, and is made chiefly of the air-bladder and sounds of different kinds of fish, especially of the sturgeon (*Acipenter Huso*). It is the finest and best of animal glues. The best quality is shaped like a lyre, another quality is in square pieces like the leaves of a book; the lowest quality is of all sorts of shapes, from its having been dried without care.

Isinglass is used for culinary purposes, for fining beer and other liquids, for making court-plaster, and stiffening silk. It should be white, inodorous, readily and completely soluble in hot water, and in cooling form a semi-transparent and solid jelly.

When a thin piece of genuine isinglass is looked through, by holding it before the eye and daylight, a sort of shining appearance, or *chatoiement*, may be observed.

Isinglass is often imitated with the intestinal membranes of the calf and of the sheep; this spurious article may be recognised, because it does not exhibit the shining appearance before alluded to when held before the light, and because, although inodorous, it has a saltish flavour, and is generally in thinner pieces than the genuine isinglass. If it be torn asunder, it will be observed that it may be rent in all directions, whilst genuine isinglass cannot be divided otherwise than in the direction of its fibres. If a piece of artificial isinglass be macerated in water, it swells; but instead of retaining its shape, as is the case with genuine isinglass, it becomes divided into small pieces, forming a sort of curdy precipitate; and if treated with boiling water, about one-third of its weight is left in an insoluble state, and the liquor does not form a good jelly.

KELP (British Barilla).—Kelp, or British barilla, is an alkali still more impure than barilla; it is obtained in this country by burning various sea-weeds, and seldom contains more than from 2 to 5 per cent. of real soda. The manufacture of kelp is carried on to a large extent in Glasgow for the utilization of the *potassium* salts which it yields.

KUPFER-NICKEL (Arseniuret of Nickel).—This mineral is the most abundant of the ores of nickel. It has a reddish colour, somewhat like copper, but it contains no copper. It is insoluble in hydrochloric acid, but it readily dissolves in nitric acid, and in aqua regia. Roasting transforms it into basic arseniate of nickel of a green colour. The constituents of this mineral are as follows:—

	Riegelsdorf		Allamont	Ayer Ht. Valais
Nickel . . .	44·20	48·90	48·80	43·80
Arsenic . . .	54·72	46·42	39·94	53·05
Iron . . .	0·33	0·34	0·00	0·45
Lead . . .	0·32	0·56	0·00	0·00
Antimony . .	0·00	0·00	8·00	0·05
Cobalt . . .	0·00	0·00	0·16	0·32
Sulphur . . .	0·40	0·80	2·00	2·13
				Gangue 0·20
	99·57 Stromeyer	97·02 Pfaff	98·90 Berthier	100·00 Ebelmen

Analysis of Kupfer-nickel (EBELMEN).—The purified mineral is treated with aqua regia. The sulphuric acid is precipitated by chloride of barium, and the excess of barium being removed by sulphuric acid, the arsenic acid is converted into arsenious acid by ebullition with sulphurous acid, and then precipitated by sulphuretted hydrogen. The sulphide of arsenic obtained is, after drying and weighing, decomposed by aqua regia, to obtain the sulphur. The liquor freed from sulphide of arsenic is concentrated with the addition of nitric acid, and is precipitated by excess of ammonia; an abundant precipitate of peroxide of iron is formed, which generally retains a little nickel. It is redissolved on the filter by hydrochloric acid, and the liquor treated cold with carbonate of barium. The peroxide of iron alone is precipitated; the carbonate of barium with which it was mixed is readily separated. The liquor containing the nickel is treated with sulphuric acid, and after filtration is added to the ammoniacal solution of the rest of the nickel: this is precipitated by excess of potassa, and, after drying and calcining, is weighed: its quantity indicates that of the metallic nickel. The ammoniacal liquor, afterwards treated with hydrosulphate of ammonium, sometimes yields a black precipitate, which, collected, calcined, and weighed, gives with borax the reaction of cobalt. ('Annales des Mines,' tome xi. p. 56.)

LAC DYE.—Lac dye is a red colouring matter extracted from stick lac in various ways. The best is manufactured from the stick lac of Siam and of Pegu. It is in pieces about 2½ or 3 inches square, and half an inch thick, of a dark purple colour. The best is marked D T, the second J Mc R, the third C E; but as these marks are imitated, it is much better not to rely upon them, but to determine the quantity of colouring matter or the tinctorial power of the article, which is done by comparison, dyeing a certain portion of wool, cloth, or flannel, as described below, and comparing the colour with that produced in the same conditions by genuine and best lac dye.

The dye-bath is prepared as follows:—

5 grains of cream of tartar (argol),
20 grains of flannel, or white cloth,
5 grains of lac dye,
5 grains of chloride of tin,
1 quart of water.

The following proportions may also be used:—

5 grains of cream of tartar (argol),
60 grains of white cloth or flannel,
5 grains of lac dye,
1 pint of water.

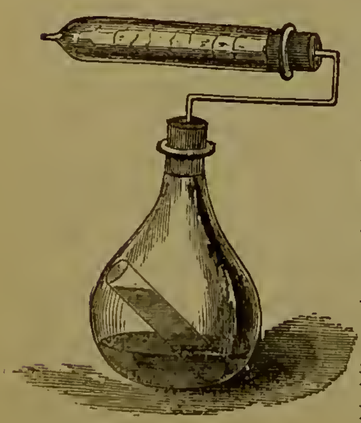
Heat the water to the boiling-point in a tin or china vessel; add thereto the cream of tartar (argol), and then the piece of cloth or of flannel, previously weighed. Weigh off 5 grains of the lac dye, and pulverize it in a Wedgewood mortar with the 5 grains (by measure) of chloride of tin, and pour the whole into the hot liquor containing the argol and the cloth, taking care to rinse the mortar with a little of the hot liquor; keep the whole boiling for at least one quarter of an hour, or even half an hour, stirring the cloth or flannel about by means of a glass or wooden stirrer. At the end of that time the cloth should be withdrawn, washed in cold water, and then dried.

LAC LAKE.—Lac lake is a colouring matter obtained from the stick lac, but is much inferior to lac dye. The process for estimating its strength, and consequently its commercial value, is the same as described for *Lac dye.*

LEAD ORES. *See* GALENA.

LIMESTONES, ANALYSIS OF.—The importance of these minerals in agriculture and in the arts renders the determination of their general composition a matter of frequent occurrence to the practical chemist. The following is the method of procedure:—Dissolve 100 grains of the specimen (which should be well selected and averaged) in dilute hydrochloric acid, and evaporate the solution to dryness on the sand-bath; moisten the residue with hydrochloric acid, let it stand for half an hour, then add boiling distilled water, and filter through a filter which has been previously dried at 212° in the water-oven, and weighed; wash on the filter till the wash water passes through tasteless, then return the filter with its contents to the water-oven, and dry, until it ceases to lose weight. The increase in weight is the *silicic acid, sand, insoluble clay,* and (perhaps also) *organic matter* in 100 grains of the limestone. It is rarely necessary to do more than determine the total amount of silicic acid in this insoluble residue, which is done by fusing it in a platinum crucible with four times its weight of mixed carbonates of potassium and sodium, and evaporating the fused mass carefully to dryness with excess of hydrochloric acid; when perfectly dry it is allowed to cool, then moistened with strong hydrochloric, boiled up with water, and filtered; the residue on the filter is pure *silicic acid*; it is well washed with boiling distilled water, dried, and ignited in a platinum crucible. The crucible should be weighed with its cover on, as silicic acid is apt to take water from the air. In the great majority of cases it is sufficient to determine the *weight* only of the ignited residue of a limestone, insoluble in hydrochloric acid, without submitting it to analysis. The filtrate from the insoluble residue, with the washings, is divided accurately into three equal parts, each part representing one-third of 100 grains of the limestone. One part is mixed in a flask with a little concentrated nitric acid, or chlorine water, to peroxidize any *iron* that may be present, heated nearly to boiling for some time, and then allowed to cool; it is now transferred to a beaker or other convenient vessel that admits of being covered with a glass plate, and ammonia added in slight excess; the precipitate which falls is *alumina* (with a little silicic acid) and perhaps *sesquioxide of iron* and *oxide of manganese*; it is collected on a filter, washed, dried, ignited, and weighed. Except for scientific (geological) objects, it is rarely necessary to submit this precipitate to analysis. In the filtrate from the precipitate by ammonia, the *lime* and *magnesia* are determined in the usual manner. In order to determine the total amount of carbonic acid, the excellent method proposed by Schaffgottsch may be followed. A known weight of the limestone is heated intensely in a platinum crucible, with four times its weight of recently fused *borax*; the loss of weight when cold indicates the amount of carbonic acid, *plus* the *water*, which the limestone may contain. The amount of the latter is determined with sufficient accuracy for all practical purposes by keeping 100 grains of the mineral in the air-bath heated to 300°, until its weight is perfectly constant; or the carbonic acid may be determined in a weighed quantity of the limestone finely pulverized, by the process of WILL and FRESENIUS (see *Alkalimetry*, p. 16); or the following simple little apparatus may sometimes be conveniently employed. It consists of a small thin-bottomed flask, capable of containing about four ounces of water. It is fitted with a cork, through which is inserted a bent tube adapted to another wide tube, containing fragments of dried chloride of calcium; the extremity of this tube is drawn out to a capillary orifice. The small tube seen inside the flask is intended to hold the sulphuric or hydrochloric acid, with which it is proposed to decompose the carbonate. It should rest against the side of the flask at an angle of about 45° from the bottom, so that by inclining the flask the whole of the acid can be made to flow out. The carbonate to be analysed is accurately weighed, and projected into the flask, which should contain about an ounce of water; and, the chloride of calcium tube having been fixed air-tight into its place,

FIG. 21.



the whole apparatus is accurately weighed. Great care must be taken that none of the acid in the tube comes into contact with the carbonate before the operation is commenced. Everything being ready, the flask is inclined so as to allow a portion of the acid to flow out of the tube; effervescence immediately takes place, carbonic acid is expelled, and escapes through the orifice of the chloride of calcium tube, being thoroughly dried during its passage through the lime salt. As soon as the effervescence has ceased, a fresh portion of acid is caused to flow out of the tube, and the operation is repeated until no further escape of carbonic acid gas is perceived.

The flask is now placed in a vessel of boiling water, where it is allowed to remain for some time in order to expel all the carbonic acid in the liquor, and in the upper part of the flask, aqueous vapour is prevented from escaping by the chloride of calcium. On cooling, atmospheric air finds its way into the flask, which is thus brought to the same condition it was in previous to commencing the experiment. It is now weighed; the loss of weight indicates the amount of carbonic acid. It will be understood that for mineralogical purposes, the residue insoluble in hydrochloric acid and the precipitate by ammonia must be submitted to minute analysis. If the limestone be intended to be used as a flux (in the iron blast-furnace, for example) it may be necessary to examine the residue insoluble in hydrochloric acid for *pyrites*; a portion of it should be fused with a mixture of carbonate of sodium and nitrate of potassium; the fused mass digested with dilute hydrochloric acid, and evaporated to perfect dryness; the dry residue moistened with a few drops of hydrochloric acid, then diluted with distilled water, filtered, and the sulphuric acid in the filtrate determined as sulphate of barium by the addition of chloride of barium.

LINEN. *See* COTTON.

LINSEED MEAL. — The linseed meal of commerce is frequently adulterated with *bran, sawdust, clay,* &c. According to SOUBERAIN, the presence of bran, which is the substance most ordinarily employed for adulterating it, may be detected by means of a solution of iodine, which produces the characteristic blue colour. But it must be remembered that pure linseed contains a small quantity of starch, and that it often accidentally contains also small grains of corn which, unless indeed the blue colour produced by iodine is very deep, might easily lead into error. The best method consists in exhausting the meal with ether, and evaporating the ether. Good and pure linseed meal should thus yield 53 per cent. of oil.

LIQUEURS. *See* Blanc Mange.

LITHARGE (Protoxide of Lead).—Litharge (protoxide of lead) is known also under the name of *massicot*, when it has not undergone fusion; after fusion it is always called *litharge*.

Commercial litharge, especially that which is foreign, such as that of Hamburg, contains sometimes a considerable proportion of *oxide of copper* and of *iron*, sometimes also a little *silver* and *silica*.

Litharge is sometimes met with in coherent masses, of a yellowish colour, in which case it is sometimes called *litharge of silver*; at other times it consists of a multitude of beautiful semi-transparent spangles, of a reddish colour, in which case it is called *litharge of gold*, and often contains a certain quantity of *minium* (red lead).

As litharge slowly absorbs the carbonic acid of the air, it generally effervesces when treated by acids, and this effervescence is stronger in proportion to its age.

The best solvent of litharge is nitric or acetic acid. When these acids fail in dissolving it completely, it is a proof that it is not pure. The principal impurity generally is silica, which thus remaining undissolved, may at once be estimated by weighing, of course after drying it.

If the litharge under examination contain any *iron*, *copper*, or *silver*, which is often the case, these substances may be detected by dissolving a known weight of the litharge in nitric acid, diluting with a very large quantity of water, and adding hydrochloric acid, which will produce a white precipitate of chloride of silver, if that metal be present; or, instead of hydrochloric acid, a solution of chloride of sodium (common salt) may be used as described in the article on silver, to which the reader is referred. Or instead of a solution of chloride of sodium, one of chloride of lead may be employed as a test for the silver; in that case, 140 grains of chloride of lead should be dissolved in 10,000 grains-measure of water, 1,000 grains of which will represent 10·8 of silver.

After having separated the chloride of silver produced by filtering, a current of sulphuretted hydrogen should be slowly passed through the filtered liquor, until it smells strongly of the gas; this precipitates the lead and the copper in the state of black sulphides, which should be collected on a filter, washed, and then cautiously treated by fuming nitric acid, which should be added in small portions at a time, to avoid too violent an action, which might cause a loss by projection, and on which account the vessel should be covered by a watch-glass or a porcelain capsule. The whole is then evaporated to dryness, and the sulphate of copper produced is separated from the sulphate of lead by treating the slightly ignited residuum with water, which redissolves the sulphate of copper. The sulphate of lead left in an insoluble state should be moderately heated until acid vapours cease to be disengaged; it is then ignited and weighed. 150 grains of sulphate of lead contain 104 of lead, or 112 of protoxide of lead; or, decimally, each grain of sulphate of lead contains 0·73563 grain of protoxide of lead, or 0·68287 grain of lead.

The presence of copper may be ascertained in the filtered solution by ammonia, which will produce a blue colour; or better still, by ferrocyanide of potassium, which will produce a reddish-brown precipitate. If so, the copper may now be precipitated from the liquor filtered from the sulphate of lead, in the manner described in the article on *Sulphate of Copper*, by means of a solution of potash.

The liquor filtered from the sulphide of lead and copper should be boiled to expel the sulphuretted hydrogen, and then with a few grains of chlorate of potassium; an excess of ammonia is then added, which will precipitate the peroxide of iron, which is collected on a filter, washed, dried, ignited, and weighed.

LOZENGES. *See* BLANC MANGE.

MADDER.—Madder is the root of a plant (*Rubia tinctorum*), of which there are several species.

Levant madder occurs in commerce in pieces externally brown, and internally of a pale orange yellow colour; the roots ordinarily sold in shops belong to this species.

Dutch and *Zealand madder* is also very much in request; the roots are generally met with in the pulverized state, because they are ground for importation.

Avignon or *French madder* is imported both whole and ground.

Munjeet is a species of madder imported from East India.

Madder is sometimes called *alizari*, which is the name given to all kinds of unground madder. *Gamene madder* (garance robée) is madder which has been dried and ground without removing the outer pellicle. *Kor, krups*, or *crops, grappe*, is ground madder, from which the outer pellicle has been removed. *Mull madder* is the worst kind of madder, and consists of the pieces which have been separated by fanning or sifting, and pulverizing the smaller roots of the other kinds; it is suitable only for the darker reds.

According to Bucholz, the constituents of madder are as follows:—

Resinous red colouring matter	1·2
Extractive ditto	39·0
Reddish-brown substance soluble in alcohol	1·9
Pungent extractive	0·6
Gummy matter	9·0
Woody fibre	22·5
Matter soluble in potash	4·6
Salts of lime with colouring matter	1·8
Water	12·0
Loss	7·4
	100·0

According to M. Ed. Kœchlin, madder-root, in the fresh state, consists of—

90·36 fleshy parts =	water	73·42
	dry matter	16·94
9·64 woody fibre =	water	4·96
	dry matter	4·68
100·00		100·00

The same chemist says that ground and dried madder-root contains—

Matter soluble in cold water	55·0
Ditto in boiling water	3·0
Ditto in alcohol	1·5
Woody fibre	40·5
	100·0

According to Chevreul, 100 parts of Levant or Turkey madder, dried at 212° Fahr., yielded 9·8 of ashes half fused.

100 parts of madder from Alsatia yielded 9·5 of pulverulent ashes.

100 parts of another sample, also from Alsatia, yielded 12·0 of pulverulent ashes.

100 parts of a third sample of madder from the same country yielded 13·5 of pulverulent ashes.

Madder is often adulterated with *brickdust, red ochre, red sand, clay, mahogany sawdust, log-wood, sandal* and *japan-wood, bran.*

The fraudulent admixture of brickdust and other earthy or siliceous matter may be easily detected by putting a portion of the sample into a large precipitating glass, and stirring it therein with about 100 or 150 times its weight of water. The madder remains suspended in the liquid, and by decanting it with suitable care, again adding water, stirring, and decanting again and again several times, nearly the whole of the earthy impurities may be separated. It is better, however, to incinerate a given weight of the madder under examination, and to compare the weight of the ashes thus obtained with those which are left when genuine madder of the same description is submitted to the same ordeal.

According to Messrs. GIRARDIN and HOUTOU LA BILLARDIÈRE, genuine madder, perfectly dried, at 212° Fahr., and from which the epidermis and all earthy matter has been removed, leaves on an average 5 per cent. of ashes. The madder of Provence, with its epidermis, yields 8·80 per cent. of ashes.

The estimation of *sawdust*, *bran*, and other such organic matter, is more difficult, and the best way is to ascertain the tinctorial power of the sample under examination. This, according to ROBIQUET and COLLIN, may be done in the following manner:—Dry the sample or samples at a steam-heat; take 25 grammes (about 400 grains) of each sample, and treat them by 200 or 250 grammes (about 3 or 4,000 grains-measure) of water, the temperature of which should not exceed 20° Cent. (68° Fahr.), for otherwise a portion of the red colouring matter would be dissolved. The whole, after having been left in contact for about three hours, is thrown upon a filter, the insoluble portion is washed with 200 or 250 grammes (3 or 4,000 grains-measure) of cold water, after which it is dried at a steam-heat, and weighed.

One part of the insoluble matter is then put into a small glass balloon, with 40 parts of water and 8 parts of alum; the whole is heated, and after boiling for a quarter of an hour the liquor is filtered whilst in the boiling state. The insoluble portion is again washed, as before, and the filtrate from the various samples is precipitated by sulphuric acid. The weight of the precipitate so produced in each liquor represents the proportion of colouring matter contained in them.

This process is based upon the insolubility of alizarine in cold water, whilst the boiling solution of alum dissolves it all. CHEVREUL, however, says that a portion remains undissolved.

Meillet's Process.—Take 20 litres of water (about 4½ gallons) heated to 60° Cent. (140° Fahr.), and dissolve therein 2 kilogrammes (about 4½ lbs.) of alum; add thereto 10 kilogrammes (about 22 lbs.) of madder; bring the whole gradually to the boiling point, and keep it boiling for half an hour. The decoction is then thrown upon a cloth filter, and strongly squeezed thereon; after having repeated this treatment three times, the madder is exhausted.

The various filtrates are mixed together and left at rest for a while, the clear portion is decanted, and before it has completely cooled the operator pours into it 625 grammes (about 10,000 grains-measure) of sulphuric acid of sp. gr. 1·848, diluted with twice its bulk of water, taking care to stir the liquor incessantly whilst pouring the acid. Thick reddish flakes are precipitated, which very soon settle at the bottom, and the liquor from purple-red becomes greenish-yellow. The supernatant liquor is then decanted, the residuum is washed several times, and a mass is left which, after drying in the air, is in the state of shining scales of a reddish-brown colour; it is *alizarine*, but not quite pure. The precipitate, whilst still moist, should be heated with one and a half its weight of carbonate of potassium dissolved in 12 or 15 times its bulk of water; the carbonate of potassium is then saturated by sulphuric acid, which produces a precipitate of a fine red colour, which, according to M. MEILLET, is pure alizarine. The madder from Avignon, when submitted to this treatment, yields 2 or 2½ per cent. of alizarine; but it is necessary in such trials to compare the result obtained with that given by madders of the same kind and name, which are known to be genuine.

Madder may also be tried by HOUTOU LA BILLARDIÈRE'S colorimeter. (This instrument has been described in the article on *Indigo.*) The experiment is performed as follows:—First dry thoroughly, at 212° Fahr., a portion of madder of a known quality, and a like weight of the sample of madder to be examined. This done, take 500 grains of each of these two portions, and mix them carefully with ten times their weight of water at 68° Fahr., and leave the whole to digest for three hours. Repeat the same operation a second time, and wash both residues with 5,000 grains-measure of water, and dry them as before. The loss indicates the weight of the gummy and saccharine matter contained in the respective samples. Introduce now 100 grains of the two samples of madder, each in a glass balloon, with 800 grains-measure of water and 100 grains of very pure alum (see *Alum*), boil the whole for a quarter of an hour, and fill the decoction whilst boiling. Wash the residuum with 50 grains-measure of water. Repeat this operation three times, and mix the three decoctions of each respective sample together. By means of the colorimeter it is then easy to appreciate the different intensity of colour; for if 100 parts of the mixed decoction of each sample be introduced into the tubes of the colorimeter, and water added to that which has the deeper tinge, until it is brought exactly to the degree of intensity of the other, the graduations on the tubes will at once indicate in what ratio they differ.

But as madder is often adulterated with pulverized dye-woods, such as log-wood, Brazil-wood, &c., other trials should be simultaneously resorted to. They consist in dyeing with a given weight of pulverized madder, known to be of superior quality, a certain quantity of cotton prepared with different mordants. The pieces of calico employed for the experiment should all be of equal weight, and about two-and-a-half or three inches square, and they should be dyed with increasing proportions of pulverized madder, from 10 grains to 150 grains; a scale of intensity of colour is thus prepared with each mordant, the degrees of which scale correspond to a known weight of the madder taken as type.

The dyeing must be performed with care as follows:—Take a suitable number of wide-mouthed flasks, and put them into a pan placed over a naked fire, and containing water at 100° or 104° Fahr. Pour into each of the flasks $1\frac{1}{2}$ pint of distilled water, also a piece of the mordanted piece of calico, and the quantity of madder required. Put a thermometer into the pan, which should now be carefully heated, avoiding variations of temperature, and in such a way that an hour and a half may elapse before the bath attains 167° Fahr. Raise then the temperature to the boiling point for half an hour. The samples of calico are then withdrawn, rinsed with cold water, and dried.

The dyed pieces of calico are then divided into two equal portions; one half is preserved in that state, the other half is immersed for half an hour at 106° Fahr., in a solution of soap, consisting of 25 grains of white curd soap, and $1\frac{1}{2}$ pint of water; the tissue is then withdrawn, rinsed with cold water, and returned to a soap-bath prepared as the above, but to which 8 grains of chloride of tin have been added. This bath is kept boiling for half an hour. The piece of calico should be carefully rinsed, dried, and kept sheltered from the light.

After having prepared a scale of colours as above directed, it is sufficient afterwards, in order to determine the value of a sample of madder, to dye pieces of calico of the same description with known weights of the madder under examination, and this value, compared with that taken as type, is then easily determined.

Instead of pieces of calico, skeins may be employed weighing 150 grains, for which from 300 to 450 or 500 grains of pulverized madder are used to form a scale of ten colours.

Alizarine or garancine may be tested in the same manner.

MAGNESIA (Calcined Magnesia).—Magnesia is the oxide of a metal called magnesium; when pure it is white, pulverulent, very light, soft to the touch, and odourless; its specific gravity is 2·3.

The magnesia which occurs in commerce is often adulterated to a considerable extent with *lime*, *alumina*, and *silica*; sometimes also it contains *carbonate of magnesium*, which latter substance is often altogether substituted for calcined magnesia.

Pure magnesia, however, should not produce any effervescence when treated by an acid; for example, hydrochloric acid. If it effervesces, it is a proof of careless preparation, the whole of the carbonic acid not having been expelled, or of adulteration with some other carbonate. The acid employed for the purpose should be diluted with water before pouring it upon the magnesia, which should be dissolved thereby without any residue whatever; all that which may remain undissolved is an impurity. It sometimes happens, however, that a residue is apparently left though the magnesia may be quite pure; this occurs when the heat employed in calcining the magnesia has been too strong, or protracted for too long a time, in which case it dissolves entirely in acids, but it takes a long time.

If the clear solution containing an excess of acid produces a white floculent precipitate, insoluble in solution of sal ammoniac, it is *alumina*, which should be rapidly filtered; and if the liquor filtered therefrom, being tested by oxalate of ammonium, produces a precipitate, it is *oxalate of calcium*, and, of course, the magnesia contained that earth. The precipitated oxalate of calcium may be collected on a filter, washed, dried, ignited, and weighed as carbonate of calcium, into which ignition has converted it. Each grain of carbonate of calcium represents 0·56 grain of lime.

The hydrochloric acid solution of magnesia should now be precipitated by solution of chloride of barium; if a precipitate is produced, a sulphate is present; the precipitated sulphate of barium so produced may be collected on a filter, washed, dried, ignited, and weighed. 117 grains of sulphate of barium represent 1 equivalent, or 40 grains of pure anhydrous sulphuric acid, and consequently 1 equivalent of any sulphate; in that case an insoluble residuum will most probably have been left when treating the magnesia with hydrochloric acid, as mentioned before. If silica was present, it will have been left also in an insoluble state.

Carbonate of Magnesium.—Commercial carbonate of magnesium is in small cubic lumps, of a fine white colour, soft to the touch, inodorous, tasteless, and of a specific gravity of 0·294.

This substance is often contaminated by *carbonate of calcium* (chalk), which either has been fraudulently mixed with it, or because the magnesian salts from which it has been obtained were naturally contaminated with salts of lime, as is the case when prepared from the mother-waters used in the manufacture of nitre and of common salt. The best is that obtained by precipitating a solution of sulphate of magnesium by one of carbonate of potash or of soda.

The presence of *carbonate of calcium* is detected by dissolving a portion of the carbonate of magnesium under examination in hydrochloric acid, filtering, saturating the excess of acid with aqueous solution of ammonia, and then adding a solution of oxalate of ammonium, which will then produce a precipitate of oxalate of calcium. The precipitate should be rapidly collected on a filter, washed, and calcined in a platinum crucible; the weight is that of the carbonate of calcium contained in the substance.

Sulphate of Magnesium (*Epsom Salts, Seidlitz Salts.*)—1. Sulphate of magnesium is a combination of sulphuric acid and magnesia, which is met with in commerce in rectangular four-sided prismatic crystals, or in masses composed of a great number of small needles, white, inodorous, and of a bitter disagreeable taste. Sp. gr. 1·66. Sulphate of magnesium is soluble in its own weight of cold water, and is insoluble in alcohol. It effloresces in the air, and when heated it fuses in its own water of crystallization. The quantity of the water of crystallization of sulphate of magnesium varies according to the temperature at which it is made to crystallize; hydrates of this salt may be obtained containing one, two, five, six, seven and twelve equivalents of water of crystallization. When sulphate of magnesium is left to crystallize at 60° Fahr., it ordinarily contains seven equivalents of water.

Sulphate of magnesium is often adulterated with sulphate of sodium; nay, this latter salt is sometimes altogether sold under the name of sulphate of magnesium. The two salts may be easily distinguished from each other, because sulphate of sodium crystallizes in long six-sided prisms more transparent than those of sulphate of magnesium, and more efflorescent; its taste is fresh, saline, and somewhat bitter. but less disagreeable than that of sulphate of magnesium; its sp. gr. is 1·349. Lastly, a solution of carbonate of potassium or of sodium, poured into a solution of sulphate of sodium, produces no precipitate whatever; whilst an abundant, bulky, white precipitate is immediately produced by that reagent in one of sulphate of magnesium.

Nothing is therefore more easy than to distinguish these two salts from each other in an isolated state; but when they are mixed together, the operator may detect it by drying a small portion of the sample, and heating it before the blow-pipe, to the flame of which it will immediately impart a strong yellow colour. If now the operator wishes to ascertain the proportion or extent of the adulteration, he should proceed as follows:—

Take a certain portion of the salt under examination, dry it at a steam-heat until reduced into a white powder, and expose this white powder, which is the effloresced sulphate, to a *moderate* red heat, in order to expel completely the water of crystallization. Take 60 grains of the ignited sulphate, and dissolve them in pure distilled water, add then an excess of solution of carbonate of potassium of sodium, and boil; allow the liquor to become cold, and collect the precipitated carbonate of magnesium upon a filter, wash it carefully with boiling water but not too long, since it is not completely insoluble in even hot water, dry it, and ignite it strongly for some time, in order to expel the carbonic acid; the residuum is pure magnesia. 60 grains of sulphate of magnesium, previously exposed to a moderate red heat, as above said, should yield 20 grains of pure magnesia, or each grain of sulphate of magnesium should yield 0·34015 grain of pure magnesia. If, therefore, the operator subtracts from the total weight of the salt under examination, and which has been subjected to experiment, the amount of sulphate of magnesium indicated by the precipitate above alluded to, the difference will, of course, show the weight of the sulphate of sodium which has been added. If, however, the operator wishes to determine the quantity of sulphate of sodium by actual experiment, he may do so by dissolving in distilled water a given weight of the suspected salt, and pouring into this solution a quantity of chloride of barium, just sufficient to precipitate all the sulphuric acid in the state of sulphate of barium, but avoiding to use an excess of chloride of barium; that is to say, the chloride of barium should be added very cautiously as long as it continues to produce a precipitate or a turbidness, but no farther. The liquor should then be warmed and left at rest until all the precipitate has settled; it is then collected on a filter, washed, and the filtrate is cautiously evaporated to dryness. The dry residuum, which consists of chloride of sodium and of chloride of magnesium, is allowed to become cold, and it is then treated in the cold with rectified alcohol, which will dissolve the chloride of magnesium, but will leave the chloride of sodium in an almost insoluble state. From the weight of the chloride of sodium left, that of the sulphate of sodium may be calculated; each grain of chloride of sodium represents 0·53010 grain of soda, and, consequently, 1·192725 grain of anhydrous sulphate of sodium. The alcohol employed should be highly rectified, for although chloride of sodium is almost insoluble in anhydrous alcohol, it is dissolved in large quantities in spirits of wine.

MAILLECHOR. *See* GERMAN SILVER.

MANGANESE.—The principal ores of manganese are—

Pyrolusite (binoxide of manganese).
Braunite (sesquioxide of manganese).
Manganite (hydrated sesquioxide of manganese).
Hausmanite (red oxide of manganese).

The first of these ores (*pyrolusite*) is the most important, and as the natural ores of manganese are mixtures of this with the lower oxides, and contain impurities, such as *earthy carbonates, peroxide of iron, alumina, silica, sulphate of barium*, &c., it is absolutely necessary that the manufacturer who uses the mineral should ascertain the quantity of *peroxide* contained in the ore, the proportion of which in the sample determines its commercial value.

Determination of the value of Commercial Oxide of Manganese.

(1.) *By estimating the amount of chlorine evolved during the solution of the ore in hydrochloric acid, the value of the oxide being in exact proportion to the quantity of chlorine produced.*

Three methods of estimating the chlorine have been recommended.

(a.) *By noting the quantity of ferrous sulphate* (ordinary green sulphate of iron) which it peroxidizes. If the oxide of manganese be perfectly pure 43.5 parts will produce 35 parts of chlorine, which will peroxidize 78 parts of crystallized sulphate of iron. Hence 25 grains of pure oxide of manganese yield chlorine sufficient to peroxidize 159 grains of sulphate of iron.

25 grains of the powdered specimen are weighed out, and a quantity not less than 359 grains of crystallized sulphate of iron. The oxide of manganese is thrown into a flask containing about one ounce of strong hydrochloric acid slightly diluted, and a gentle heat applied. The sulphate of iron is gradually added in small quantities to the acid, so as to absorb the chlorine as it is evolved, and the addition of that salt continued till the liquor, after being heated, gives a *blue* precipitate with *ferricyanide of potassium*, and has no smell of chlorine, which are indications that the sulphate f iron is present in excess; by weighing what remains of this alt, the quantity that has been added is ascertained, say *m* grains. f the whole of the specimen consisted of peroxide, it would equire 159 grains of protosulphate of iron, and that quantity ould therefore indicate 100 per cent. of peroxide ; but, if a *poron* of the manganese only is peroxide, a proportionally smaller uantity of the protosulphate will be consumed, and that quantity ill give the real proportion of peroxide, by the proportion, as 59 : 25 : : *m* to the quantity required.

(b.) The chlorine evolved is passed through water in which me is diffused ; *chloride of lime* is formed; a certain quantity of sulphate of iron is dissolved in water, and the solution of chloride of lime is added thereto, until the iron liquor ceases to strike a blue colour with a drop of solution of ferricyanide of potassium; then, comparing the quantity of the solution of chloride of lime required with the quantity that was produced, the quantity of chlorine generated, and hence the total quantity of available oxygen is known.

(c.) Baumann conveys the chlorine into a solution of nitrate of silver, and calculates the amount of real peroxide of manganese in the specimen from the quantity of chloride of silver formed.

(2.) *By converting Oxalic Acid into Carbonic Acid, by means of the second atom of Oxygen which the Peroxide of Manganese contains.*—100 grains of the specimen are introduced into a weighed flask, and 150 grains of oxalic acid dissolved in 500 grains of water are poured upon it; to this, 350 grains of oil of vitriol are to be added, and the orifice of the flask closed by a cork, through which passes a tube containing fragments of recently fused chloride of calcium: the weight of this cork and tube are to be included in the tare of the flask. On the addition of the oil of vitriol, a brisk effervescence takes place, owing to the escape of carbonic acid, which passing over the fragments of chloride of calcium in the tube is dried, so that the gas alone passes off. When the action slackens, a gentle heat may be applied, until all the oxide of manganese has dissolved; the small quantity of a light brownish sediment, which generally falls, is easily distinguished from the particles of black oxide. As soon as the action is quite over, the flask is allowed to cool, and as it still contains a quantity of carbonic acid gas, this is removed by taking out the cork, and blowing air gently into the flask by a glass tube; the cork is then to be replaced, and the flask with its contents weighed; the difference of weight represents the amount of carbonic acid evolved, *one-fourth* of the oxygen of which had been derived from the peroxide of manganese by its conversion into protoxide, which remains combined with sulphuric acid in the liquor, and the quantity of peroxide in the 100 grains of the one are thus directly found. *Example.*—Suppose the flask and the materials together to weigh 1876 grains, and after the action has terminated 1816·5 grains; the loss, 59·5 grains, is carbonic acid, consisting of 16·3 grains of carbon, and 43·2 grains of oxygen; the oxygen derived from the mineral is therefore $\frac{43·2}{4} = 10·8$, which represents 59 grains of pure peroxide of manganese in 100 grains of the substance experimented upon.

(3.) *Method of Fresenius and Will.*—This is founded on the same principle. A certain weighed quantity of the finely powdered manganese ore is projected into B (Fig. 9), and about 2½ parts of *neutral oxalate of potassium* (prepared by saturating the common binoxalate with carbonate of potassium and crystallizing), or two parts of neutral oxalate of sodium, and as much water added as will fill about one-third of the flask; the apparatus is then prepared as directed in p. 16; B is then closed, the apparatus weighed, and, by sucking the tube *e*, some sulphuric acid is made to pass from *a* into *b*. The evolution of carbonic acid commences immediately, and in a very uniform manner; as soon as it stops, some more sulphuric acid is sucked over from *a* into *b*, and the operation thus continued till all the manganese is completely decomposed; this operation will require from six to ten minutes; its completion is ascertained not only by no further evolutions of carbonic acid taking place upon a further influx of sulphuric acid into *b*, but also by no black powder remaining at the bottom of the flask. Some more sulphuric acid is then sucked over into *b*, in order to heat the fluid contained therein, so as completely to expel all the carbonic acid evolved during the course of the operation; the wax stopper is then removed from *a*, and the tube *d* sucked until the air no longer tastes of carbonic acid; the apparatus is then allowed to cool, and weighed. The entire examination may thus, according to the authors, be performed in a quarter of an hour; from the loss of weight of the apparatus (the amount of carbonic acid expelled) the amount of available oxygen is found, or, what in fact is the same, the amount of peroxide contained in the manganese under examination, according to the following arrangement:—*Two* equivalents of carbonic acid stand to one equivalent of peroxide of manganese in the same proportion as the amount of carbonic acid stands to x, x, being the quantity of real peroxide contained in the specimen. Let us suppose that our experiment had been made with four grammes (61.76 grs.) of manganese ore, and that we had obtained 3·5 grammes (54·03 grs.) of carbonic acid. The arrangement would be—

$$4 : 43{\cdot}67 :: 3{\cdot}5 : x$$
$$x = 3{\cdot}47.$$

Thus, four grammes of the manganese ore containing 3·47 grammes of peroxide, 100 parts of the same substance must contain 86·7 parts. To render, however, this calculation unnecessary, we need only ascertain what amount of manganese must be taken to make the number of centigrammes of carbonic acid obtained immediately indicate the percentage amount of peroxide. The calculation must therefore be—

$$4 : 43{\cdot}67 :: 100 : x$$
$$x = 0{\cdot}993.$$

Thus, if we take 0·993 grammes (15·33 grains) of the specimen, the number of centigrammes of carbonic acid expelled will indicate the percentage amount of peroxide. But as the quantity of carbonic acid obtained would be too minute to admit of a direct determination of its weight, it is advisable to take a multiple of 0·993 grammes, and to divide the number of centigrammes of carbonic acid obtained by the same number, which has served as a multiplier. The multiple by 3, *i.e.* 2·98 grammes, is deemed by the authors the quantity best adapted for the examination. Should the manganese contain carbonated alkaline earths, which is sometimes the case, it must undergo a preliminary process previous to the examination. To ascertain the presence or absence of carbonate of calcium or barium in the manganese under examination, it is sufficient to moisten a sample powder with dilute nitric acid; their presence is certain if any effervescence take place. The specimen, in that case, is treated as follows:—2·98 grammes of the specimen are projected into *b*, covered with very dilute nitric acid, one part acid to twenty parts of water, and allowed to stand at rest for a few minutes; the supernatant fluid is then poured upon a small paper filter, the manganese remaining in the flask is repeatedly washed with water, as well as the solid particles on the filter (the supernatant water being always poured on the filter), and the latter then thrown into *b*, taking care not to lose a particle of manganese; the further operation is conducted as usual. The neutral oxalate of potassium is preferable to free oxalic acid, or to binoxalate of potassium, since, when employing the former substance, the evolution of carbonic acid commences only upon the influx of sulphuric acid into *b*, whilst free oxalic acid, or binoxalate of potassium, begin to evolve carbonic acid immediately upon coming into contact with manganese and water; and this would, of course, interfere with the correctness of the results, rendering it almost impossible to determine the exact weight of the apparatus before the commencement of the operation. Such is the method of examining ores of manganese proposed by the German chemists: the results are most accurate, and the manipulation is simple. It will be observed that, from the almost absolute identity of the equivalent number of carbonic acid multiplied by 2, 22 × 2 = 44, with that of peroxide of manganese, 43·67, the calculation of the quantity of real peroxide in a specimen of manganese becomes a problem of the utmost simplicity; and that if we take 100 grains of the specimen, the loss of weight in *grains* will denote the percentage proportion of pure peroxide. One atom of peroxide of manganese, ($Mn\ O_2$) = 43·67, contains one atom of oxygen. separable by sulphuric acid, and capable of converting one atom of oxalic acid into two atoms of carbonic acid.

Dr. URE recommends 250 grains of oxalate of potassium to 100 grains of the sample.

Various other methods of ascertaining the value of commercial oxide of manganese have been proposed; but as none of them exceed in accuracy or convenience the method of WILL and FRESENIUS just described, the principles of the processes alone will be briefly dascribed.

(4.) *Method founded on the reducing action of Protochloride of Tin* (L. MULLER, 'Ann. der Chem. und Pharm.' Oct. 1851, and 'Chem. Gaz.,' vol. x. p. 75).

Protochloride of tin (stannous chloride) and perchloride of iron (ferric chloride) react mutually on each other, thus—

$$Sn\ Cl_2 + Fe_2\ Cl_6 = Sn\ Cl_4 + 2\ Fe\ Cl_2.$$

In order to derive advantage from this reaction, two courses night be followed: first, a solution of protochloride of iron (ferrous chloride) might be converted into perchloride of iron (ferric chloride) by the action of the chlorine developed from ıydrochloric acid by the oxide of manganese to be valued, and hen the quantity of perchloride of iron thus formed in the olution determined by means of a solution containing a known roportion of protochloride of tin; or secondly, the chlorine volved may be passed through a solution of protochloride of tin, nd the perchloride produced estimated by means of a solution of erchloride of iron of known strength. The author finds the econd method to be perfectly applicable in practice, as the chlorine s rapidly and completely absorbed by a solution of protochloride f tin.

(5.) *Method founded on the Conversion of Arsenious Acid into Arsenic Acid by means of Chlorine and Permanganate of Potassium* (ASTLEY PRICE, 'Chem. Gaz.,' vol. ii. p. 416).

Ten or any number of grains of the specimen under examination are placed in a small flask, to which ten or more measures f a normal solution of arsenious acid in hydrochloric acid are dded, and to the flask is adapted a WILL's nitrogen apparatus ontaining a solution of potassa, to retain any terchloride of arsenic which may be given off. The flask is then placed in a water-bath, or a gentle heat is applied until solution is effected. The contents of the flask, after being allowed to cool, are, together with the solution of potassa, transferred to a larger flask and diluted with water. The amount of arsenious acid remaining unchanged is then determined by the addition of a standard solution of permanganate of potassium, and the quantity thus indicated being deducted from the number of grains of arsenious acid employed in the first instance, will give the value of the specimen under analysis.

(6.) *Method founded on the Conversion of Copper into Dichloride by the Chlorine evolved from Hydrochloric Acid by Oxide of Manganese.* (NOLTE, 'Chem. Gaz.,' vol. xvii. p. 296.)

Every atom of peroxide in the ore sets free one atom of chlorine from hydrochloric acid, which in its turn converts two atoms of copper into dichloride. Strong chemically pure hydrochloric acid is poured over a known quantity of the native peroxide in a retort, and an excess of copper is added, the evolution of free chlorine being avoided by keeping the retort as cool as possible until the ore is completely decomposed. The mixture is then heated to the boiling point, so as to convert the protochloride at first formed into dichloride. The loss of copper in weight gives the amount of peroxide in the ore, since every two atoms of copper dissolved answer to one of peroxide.

Messrs. SHERER and RUMPF (CROOKES' 'Select Methods in Chemical Analysis'), after examining all the most approved methods in Dr. FRESENIUS' laboratory at Wiesbaden, have come to the conclusion that *Bunsen's* method is the best for rapidly giving the amount of available manganese in an ore. This process is carried out by dissolving a weighed quantity of the sample in strong hydrochloric acid in a small flask until complete decomposition has taken place. The escaping chlorine is received in a strong solution of *iodide of potassium*, and the liberated *iodide* subsequently estimated by means of a standard solution of *hyposulphite of sodium* and a solution of *starch*. To prevent the solution of iodide of potassium from being sucked back into the generating flask, a few small pieces of *magnesite* are introduced with the manganese, so that a continual slight escape of carbonic acid takes place through the solution. The solution of hyposulphite of sodium is tested by means of carefully prepared pure *iodine* dissolved in iodide of potassium. The solution should be of such a strength that 1,000 c.c. of hyposulphite of sodium corresponds to from two to three grammes of binoxide of manganese.

In this estimation the iodine liberated by the chlorine should be tested as soon as possible after the decomposition: it gives higher results after standing twenty-four hours than before. These higher results are caused by the liberation of iodine by spontaneous decomposition of hydriodic acid set free by hydrochloric acid distilled over during the process.

Messrs. SHERER and RUMPF have made the suggestion that the value of manganese ores should be measured by *chlorometrical* degrees rather than by the actual percentage of binoxide, thus tending in the same direction as the resolution passed by the Association of Alkali Makers in 1869, 'That as the testing of manganese, according to the method of WILL and FRESENIUS, is, in the opinion of the meeting, incorrect, and yields uncertain results, it is recommended to the members of this Association not to buy by that test.'

Dr. PAUL adopts MOHR'S method of using a known quantity of a standard solution of oxalic acid together with excess of sulphuric acid for dissolving the ore, if necessary, boiling until the ore is completely dissolved, and then by a standard solution of *permanganate of potassium* determining the quantity of oxalic acid remaining undecomposed. This method is very convenient for testing manganese ores, and involves only one weighing for each test, and the results obtained are very uniform. It also has the advantage of giving results which fairly represent the amount of *available* peroxide in manganese ores, for any iron that may be present, as metal, or protoxide, would consume an equivalent quantity of permanganate solution, and thus apparently reduce the quantity of oxalic acid decomposed by the peroxide to an extent proportionate to the amount of iron existing in the ore. Thus, for instance, if the quantity of oxalic acid decomposed by 100 grains of manganese ore free from iron and protoxide of iron were 109·53 grains, the ore would contain 76·5 per cent. of peroxide, and the whole of that would be available; but if the 100 grains of ore also contained 5·6 grains of metallic iron or an equivalent of protoxide, the permanganate solution required for peroxidizing that iron would represent 6·3 grains of oxalic acid, and the quantity of oxalic acid decomposed by the peroxide would appear so much less than it really was, or 103.23 grains instead of 109·53 grains. Accordingly, the amount of peroxide would be represented as 72.2 per cent. instead of 76·5 per cent., and that would in fact be the amount of peroxide available for generating chlorine.

The method recommends itself by its simplicity, and by the fact that the standard solutions of oxalic acid and permanganate will keep for a long time without alterations in value. The oxalic acid solution contains 63 grammes in a litre, and 1 c.c. is equivalent to 5 c.c. of the permanganate solution.

Pattinson's Modification of Otto's Process for the Valuation of Manganese.—30 grains of clean iron wire are placed in a 20-oz. flask along with 3 oz. of dilute sulphuric acid, made by adding 3 parts of water to 1 of oil of vitriol; a cork, through which passes a tube bent twice at right angles, is inserted in the neck of the flask, and the flask is heated over a gas flame until the iron is dissolved. The bent tube is placed so as to dip into a small flask or beaker containing a little water. When the iron is quite dissolved, 30 grains of the finely-powdered and dried sample of manganese ore to be tested are put into the flask, the cork replaced, and the contents again made to boil gently over a gas flame until it is seen that the whole of the black part of the manganese ore is dissolved; the water in the flask or beaker is then allowed to recede through the bent tube into the larger flask, more distilled water added to rinse out the small flask or beaker and bent tube, the cork well rinsed, and the contents of the flask made up to about 8 or 10 ozs. with distilled water. The amount of iron remaining unoxidized in the solution is then ascertained by means of a standard solution of bichromate of potassium. (See *Iron Ores.*) The amount the bichromate indicates, deducted from the amount of iron used, gives the amount of iron which has been peroxidized by the manganese ore, and from this can be calculated the percentage of peroxide of manganese contained in the ore. Thus, supposing it were found that 4 grains of iron remained unoxidized, then $30 - 4 = 26$ grains of iron have been oxidized by the 30 grains of ore. By a simple calculation it is found that these 26 grains of iron are equivalent to 20·43 grains of peroxide of manganese, the amount of peroxide in 30 grains of ore. The percentage is therefore 68·10.

The kind of iron wire which answers best for these analyses is that used by wire-workers, and known as 'annealed iron wire.'

The length of time required to decompose the manganese ore depends upon the hardness of the sample. Soft ores will decompose in a minute or two, while very hard ores require fifteen minutes or more. The standard bichromate of potassium solution is made so that 1,000 fluid-grains will peroxidize 10 grains of iron. If there is reason to suppose that the ore to be tested contains more than 78 per cent. of peroxide, it will then of course be necessary to use less than 30 grains of ore, or more than 30 grains of iron, as these quantities are only intended for ores of a lower percentage than about 78.

MANNHEIM GOLD. *See* BRASS.

MANURES, ANALYSIS OF.—(1.) **Guano.**—The extensive use of this complex manure, its high price, and the consequent inducement held out to unprincipled vendors to sophisticate it, render it a matter of importance that the real value of a sample, as a fertilizing agent, should be capable of being tested, without submitting it to the costly and tedious process of an elaborate analysis. 'Impositions,' says Professor JOHNSTON ('Elements of Agricultural Chemistry'), 'have been practised on unwary farmers, by selling as genuine guano artificial mixtures, made to look so like guano that the practical man in remote districts is unable to detect it. A sample of such pretended guano, which had been sown in the neighbourhood of Wigtown, and had been found to produce no effect upon the crops, was examined in my laboratory, and found to contain, in the state in which it was sold, more than half its weight of *gypsum*, the rest being *peat* or *coal-ashes*, with a little *common salt*, *sulphate of ammonium*, and either dried *urine*, or the refuse of the *glue* manufactories, to give it a smell. I could not satisfy myself that it contained a particle of real guano.' Again he says, 'Four vessels recently sailed hence (Liverpool) for guano stations, ballasted with *gypsum* (plaster of Paris); this substance is intended for admixture with guano, and will enable the parties to deliver from the vessel a nice-looking and light-coloured article. Parties purchasing guano are very desirous of having it delivered from the vessel, as they believe that they thereby obtain it pure. The favourite material for the adulteration of guano is *umber*, which is brought from Anglesea in large quantities. The rate of admixture, we are informed, is about 15 cwts. of umber to about 5 cwts. of Peruvian guano, from which an excellent-looking article, called African guano, is manufactured.'

In selecting a guano, the following points ought to be attended to by the farmer (ANDERSON, 'Elements of Agricultural Chemistry'):—

1. The guano should be light-coloured and dry, cohering very slightly when squeezed together, and not gritty.

2. It should not have too powerful an ammoniacal smell, and should contain lumps which, when broken, appear of a paler colour than the powder.

3. A bushel should not weigh more than from 56 to 60 lbs.

These characters are, however, imitated with great skill, so that they cannot be implicitly relied upon, and they are applicable to Peruvian guano only. The following are the chief adulterations in guano, which chemical analysis alone can detect:—A sort of *yellow loam*, very similar in appearance to guano, *sand*, *brickdust, chalk, umber, gypsum, common salt,* and occasionally also ground *coprolites* and inferior guano. These substances are rarely used singly, but are commonly mixed in such proportions as most closely to imitate the colour and general appearance of the genuine article. The adulteration always takes place in large towns, because it is only there that facilities exist for obtaining the necessary materials, and carrying it out without exciting suspicion. 'The sophisticated article,' observes ANDERSON, 'then passes into the hands of the small country dealers, to whom it is sold with the assurance that it is genuine, and analysis quite unnecessary. In other instances, adulterated and inferior guanos are sold by the analysis of a genuine sample; and sometimes an analysis is made to do duty for many successive cargoes of a guano which, though all obtained from one deposit, may differ excessively in composition. In the case of a Peruvian guano, a complete analysis is not necessary; but an experienced chemist, by the application of a few tests, can readily ascertain whether the sample is genuine. Where the difference in value between different samples is required, a complete analysis is necessary, and this is indispensable in the case of inferior guanos.'

Analysis.—The following points should be attended to in the chemical examination of this manure, the sample being mixed as uniformly as possible, and kept in a well-stoppered bottle:—

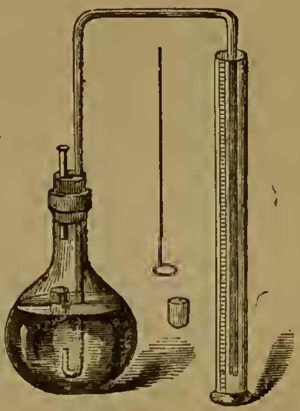
I. *Determination of the Water.*—Dry 100 grains in the water-oven till it ceases to lose weight. A great difference is here found, even in genuine guanos, the margin extending from 7 to 20 per cent.

II. *Determination of Total Amount of Fixed Constituents.*—Incinerate 50 or 100 grains, at a low red-heat, in a porcelain or platinum crucible till the weight remains constant: the residue (which will of course vary greatly according as the guano is ammoniacal or phosphoric) should be white or grey; a yellow or red colour indicates a probable adulteration with *loam, brickdust,* or *sand.*

III. *Determination of the Total Amount of Ammonia.*—The alkalimetrical method of PELIGOT gives excellent results; it involves, however, the operation of distillation. This is obviated by the following modification of the process, which is particularly applicable to the analysis of guano, and ammoniacal manures generally:—A weighed quantity (say 20 grains) of the guano is placed in a shallow glass vessel, about four inches in diameter, standing in a plate filled with mercury; on a glass triangle, laid across the dish containing the guano, is placed a second dish, containing a measured volume of standard sulphuric acid; a few drachms of water are then thrown on the guano, and then some milk of lime, by means of a pipette; the whole is now covered with a beaker, and allowed to remain for two or three days, or until reddened litmus-paper is no longer affected when introduced within the glass. The whole of the ammonia has now been expelled from the guano without the aid of heat, and has been absorbed by the acid; the quantity of which left free is determined by means of a standard solution of soda, and the amount of ammonia calculated from the result.

IV. *Determination of the Total Amount of Nitrogen.*—The following method, though only an approximative one, recommends itself by the facility with which it is executed, and the rapidity with which it enables the operator to ascertain the comparative values of different specimens of guano. It is founded on the fact that, when guano is treated with a solution of *chloride of lime*, the nitrogen both of the organic matter and of the ammoniacal salts is evolved as gas. Instead of collecting and measuring the gas evolved, which would be scarcely practicable on account of the violent effervescence, the volume of water which is expelled by the gas is ascertained by means of the simple apparatus represented in the figure; it consists of a flask capable of containing about half a pint, provided with a narrow gas delivery tube, bent twice at right angles. One limb, rather the shorter of the two, is passed air-tight through the cork of the flask, and bent upwards, to prevent as far as possible the escape of bubbles of gas. This tube descends nearly to the bottom of the flask. A second very narrow short tube is also passed through the cork, and serves for the escape of air when the cork is introduced. The longer limb of the delivery tube dips into a tall cylinder or tube, which is graduated to cubic centimètres or cubic inches. The flask is half filled with solution of chloride of lime, carefully prepared and kept in a dark place in a closed vessel. About fifteen or twenty grains of guano are then weighed in a small glass vessel, which may be the end of a test tube, in which a few small shot have been placed in order that it may float. With the aid of the iron-wire handle, shown in the figure, the tube is let down so as to float upon the surface of the solution of chloride of lime, the cork with the tube is then tightly adjusted, the orifice of the smaller tube closed with wax, and the flask shaken so that

FIG. 22.



the little vessel may fill and sink; a volume of liquid, equal to the nitrogen evolved from the guano, then flows into the graduated cylinder: when no more liquid passes over, the cylinder is depressed so as to bring the liquid to the same level as that in the generating flask. The wax plug is then removed, the cork withdrawn, and the liquid still contained in the delivery tube is allowed to run into the cylinder, where the whole is carefully measured. Fifteen grains of good Peruvian guano evolve between four and five cubic inches of gas. A more exact determination of the amount of nitrogen is obtained by burning a known quantity of the manure with soda lime, according to WILL and VARRENTRAPP's method, as modified by PELIGOT.

V. *Determination of the Constituents, Soluble and Insoluble in Water.*—Digest 150 or 200 grains with several times its volume of water; throw on a previously dried and weighed filter, and wash till a few drops of the wash-water collected in a test tube are not rendered turbid by the addition of ammonia and chloride of calcium; the filter, with the washed guano, is then thoroughly dried in the water-oven and weighed. The difference, less the proportion of water found in (I.), gives the amount of solid constituents. Burn the insoluble matter and weigh the ash, which represents the amount of fixed insoluble salts.

VI. *Sand.*—Dissolve the ash in dilute hydrochloric acid: if it effervesce *strongly*, there is reason to suspect an adulteration of *chalk*; a good guano only gives rise to slight effervescence. The residue, after being well washed, dried, and gently ignited, is weighed as sand; it should not exceed 2 per cent.

VII. *Determination of Phosphate of Calcium.*—On adding slight excess of ammonia to the hydrochloric solution of the ash, this salt falls; it is filtered off, washed, dried, ignited, and weighed. The filtrate from the precipitate by ammonia should give, on the addition of oxalic acid, only slight indications of *lime*. If, however, a considerable precipitate occurs, the guano has certainly been adulterated with chalk, the amount of which must be determined. Should it be desired to ascertain the exact amount of phosphoric acid, the hydrochloric solution of the ash should be *nearly* neutralized by ammonia, then oxalate of ammonium added, and the solution boiled, acetate of ammonium in excess being added to the boiling liquid. On standing, oxalate of calcium precipitates, and is removed by filtration, and the phosphoric acid in the clear filtrate is determined as pyrophosphate of magnesium.

VIII. *Determination of Alkaline Salts.*—For practical purposes, it is only necessary to evaporate the filtrate from the phosphate of calcium to dryness, and weigh the residue after gentle ignition, to expel the ammoniacal salts, calculating it as 'alkaline salts;' when, however, *chalk* has been found as an adulteration, it must of course be previously removed by oxalic acid.

By way of reference, we append some analyses of the highest and lowest qualities of some *genuine* guanos, on the authority of Professor ANDERSON ('Elements of Agricultural Chemistry,' p. 210).

	Angamos		Peruvian		Bolivian	
	Highest	Lowest	Highest	Lowest	Highest	Lowest
Water	12·60	7·09	10·37	21·49	11·53	16·20
Organic matter and ammoniacal salts	65·62	50·83	55·73	46·26	11·17	12·86
Phosphates	10·83	8·70	25·20	18·93	62·99	52·95
Alkaline salts	7·50	16·30	7·50	10·64	9·93	13·83
Sand	3·45	17·08	1·20	2·68	4·38	4·16
	100·00	100·00	100·00	100·00	100·00	100·00
Ammonia	25·33	17·15	18·95	14·65	1·89	2·23

The following is the composition of (so-called) Peruvian guano, which has evidently, however, been adulterated, and which is worth less than half the price of the genuine manure:—

Water	12·06
Organic matter and ammoniacal salts	34·14
Phosphates	22·08
Gypsum	11·08
Alkaline salts	12·81
Sand	7·83
	100·00

(2.) **Superphosphate of Calcium.**—'The deliberate adulteration of superphosphates,' observes Professor ANDERSON, 'that is, the addition to it of sand or similar worthless materials, I believe to be but little practised. The most common fraud consists in selling as pure dissolved bones, articles made in part, and sometimes almost entirely, from *coprolites.* Occasionally refuse matters are used, but less with the intention of actually diminishing the value of the manure than for the purpose of acting as driers. It is said that sulphate of calcium is sometimes employed for this purpose, but this is rarely done, because that substance is always a necessary constituent of superphosphate in very large quantities; and as farmers look upon it with great suspicion, all efforts of the manufacturers are directed towards reducing its quantity as much as possible.'

There is no manure which requires greater vigilance on the part of the purchaser than superphosphate of calcium, because of the great variations in quality; though, in consequence of increased competition, and the process of manufacture being better understood, it is much better than it was a few years ago.

Analysis.—The following are the points to be attended to in the chemical examination of this manure:—

I. *Determination of the Water.*—50 grains are dried in the air-bath, at a temperature of about 300° F., until the weight remains constant; the loss represents the amount of moisture absorbed by the superphosphate, and the water in the gypsum.

II. *Determination of the Relative Proportion of Soluble and Insoluble Constituents.*—150 grains of the sample are boiled up with water, and allowed to settle; the decanted fluid is thrown on a filter, and the residue again and again boiled with water, until there is no longer an acid reaction. The insoluble matter is then dried in the air-bath at about 300° F., and weighed. Of course, any solid particles that may have been retained on the filter are added; this is best done by drying and burning the filter, and adding the ash.

III. *Determination of the Organic Matter in the Insoluble Portion.*—Moisten with a little nitric acid, to peroxidize any iron that may be present, then ignite at a low red-heat in a platinum crucible, placed sideways, so as to allow air to have access; when cold, weigh. The loss represents the amount of organic matter, *plus* that of any ammoniacal salts that may have been present.

IV. *Analysis of the Insoluble Matter.*—Boil for some time with dilute hydrochloric acid, dilute largely, and boil again; filter, wash, dry, ignite, and weigh the residue on the filter, which is *sand* and *clay.* Mix the filtrate and washings well together, and divide into three parts—*a*, *b*, *c*. In *a* determine the *sulphuric acid* (from the gypsum) by *chloride of barium*; mix *b* and *c* together, add *oxalate of ammonium*, and considerable excess of *acetate of ammonium*, and boil. All the lime is hereby precipitated as oxalate; it is collected on a filter, and estimated as sulphate. To the filtrate from the oxalate of calcium add tartaric acid and ammoniacal sulphate of magnesium, which precipitates the phosphoric acid as ammonio-magnesian phosphate. Combine the sulphuric acid found in *a* with the quantity of lime requisite to form *gypsum* (40 sulphuric acid + 28 lime); add the remainder of the lime to the phosphoric acid, and enter it as 'insoluble phosphate.'

V. *Analysis of the Soluble Portion.*—Divide into three equal parts—*a*, *b*, *c*; transfer *a* to a platinum dish, and evaporate gently on the sand-bath, adding, a little at a time, thin *milk of lime*, until a piece of red litmus-paper is turned faintly but distinctly blue, showing an alkaline reaction; continue the evaporation to perfect dryness, transfer to the air-bath, dry at 320° F., and then weigh; ignite, and weigh again. The difference between the results of the two weighings expresses the quantity of *organic matter* in the aqueous solution. Boil the ignited residue with lime-water, and then with distilled water, for a considerable time; remove the sulphuric acid from the filtrate by chloride of barium, and then the excess of the barium and calcium salts by carbonate of ammonium, and filter. The filtrate contains nothing but the *alkalies*, which are determined in the usual manner. Determine the sulphuric acid in *b* by chloride of barium; evaporate *c* to dryness in a platinum dish with excess of carbonate of sodium, and add a little nitre; ignite the residue, rinse into a beaker, and dissolve in hydrochloric acid with the aid of a gentle heat. To the clear solution add ammonia, and then *acetic acid* in excess. If any *phosphate of sesquioxide of iron* be here precipitated, filter it off, and divide the filtrate into two equal parts—in one determine the phosphoric acid by the *acetate of protoxide of uranium*; the liquid should be boiled after the addition of this reagent, and the precipitate allowed to subside. FRESENIUS recommends the addition of a drop or two of *chloroform* immediately after the precipitation, and when the liquid has cooled a little, giving the mixture a vigorous shake, which materially assists the precipitation of the finer particles; these are collected on a filter, the bulk of the precipitate being washed by decantation; the well-washed precipitate is dried and ignited; the filter is also dried and burnt, and its ashes added to the ignited precipitate, 100 parts of which contain 19·78 parts of phosphoric acid. Determine the calcium and magnesium in the other portion of *c* in the usual manner.

It is convenient to keep on hand a stock of *tartarized ammoniacal sulphate of magnesium* for phosphoric acid determinations. The following proportions may be used:—

2	pints of water.	
225	grains of tartaric acid.	
80	,,	anhydrous sulphate of magnesium.
250	,,	chloride of ammonium.

Those engaged in the frequent analysis of superphosphates of calcium, and other phosphatic manures, will find it convenient to estimate the phosphoric acid by a volumetric process. A good method is the following:—

By Acetate of Uranium (PINCUS, ‘Journ. für Prakt. Chemie,’ lxxvi.).

A solution of phosphate of sodium, the amount of phosphoric acid in which is accurately known, must be prepared; its strength should be such that each cubic centimètre exactly represents 0·01 of phosphoric acid. The acetate of uranium is prepared by dissolving pure ammonio-carbonate of uranium in acetic acid; it must be perfectly free from protoxide, to ensure which the solution must be protected from the light. The strength of the solution is determined by pouring 5 to 10 cubic centimètres of the solution of phosphate of sodium into a beaker, adding ammonia and an excess of acetic acid, and then pouring the solution of uranium from a burette with divisions of $\frac{1}{10}$th to $\frac{1}{20}$th cubic centim., stirring the mixture frequently during the process. The peculiar slimy precipitate of phosphate of uranium and ammonium is produced. From time to time a drop of the mixture is put upon a white porcelain plate, close to a drop of solution of ferrocyanide of potassium, and the two drops are allowed to flow together. As long as the phosphoric acid is not all precipitated, only a bluish-green colour is produced; but when the smallest excess of oxide of uranium is present, the spot which is at first bluish-green becomes distinctly surrounded with a darker or lighter chocolate-coloured border. If the solution be very dilute, the reaction disappears again in a few minutes, after strong stirring; a further quantity of the solution of uranium must then be added. If the brownish-red colour has remained permanent for ten minutes, it does not again disappear, but makes its appearance still more distinctly, without any admixture of yellow and green, when, after the settlement of the slimy precipitate, a drop of the clear supernatant fluid is employed for the reaction. When it has been clearly ascertained by repeated experiments how many cubic centimètres of the solution of uranium are necessary for the precipitation of 0·05 or 0·10 gramme of phosphoric acid, the solution may by calculation, and by adding water, be brought nearly to such a state of dilution that each cubic centimètre thereof may precipitate the phosphoric acid contained in one cubic centimètre of that solution, namely, 0·10 gramme. By repeated experiments, and by the addition of small quantities of water, or of a concentrated solution of oxide of uranium, it may be easily managed that the two solutions may be equivalent within the limits of $\frac{1}{10}$th to $\frac{1}{20}$th cubic centimètre, for quantities of 10 to 20 cubic centimètres; so that the highest possible error may lie within the limits of 0·0005 and 0·001 gramme of phosphoric acid.

To apply this method, the solution containing the phosphoric acid to be determined is mixed, whether neutral or acid, with ammonia, acetate of sodium, and then with acetic acid in excess.

Every $\frac{1}{10}$th cubic centimètre of solution of oxide of uranium employed until the production of the reaction, represents 0·001 gramme of phosphoric acid; the deposition of the precipitate is facilitated by heating the solution. The solution must not contain either protoxide of iron or alumina.

Another volumetric process, which is exceedingly simple, and has afforded satisfactory results, is described by Mr. BARNARD (CROOKES's 'Select Methods in Chemical Analysis'). Suppose a superphosphate made in the usual manner, in such a manure the *bone phosphate* may be measured by the quantity of sulphuric acid employed in its solution. Extract all that is soluble in water from 100 grains of the manure, and divide it into two equal volumes of 1,000 septems each in a beaker of the same dimensions. Into one drop a standard solution of carbonate of sodium from a burette, when a precipitation of bone phosphate occurs; this, however, on gently moving with a stirrer, is redissolved: continue to drop in until there is a faint trace of a permanent precipitate, which may be the better detected by comparison with the other volume in the second beaker. When sufficient carbonate of sodium has been added, then, after duly noting the number of septems employed, an additional septem may be dropped in, when a decided milkiness and agitation will be manifest. The number of septems thus employed is the measure of the free acid existing in the manure. A little practice will enable the operator to determine very nicely the point of incipient precipitation. Now throw in a piece of litmus-paper—if blue, it instantly turns red—and then continue the soda dropping until the red litmus becomes nearly blue. A few minutes' repose will allow sufficient time for the precipitate to somewhat settle down, leaving a clear space above; into this a drop of carbonate of sodium solution may be carefully let down, when, if further precipitation occurs, more carbonate may be added, the whole stirred, and allowed to subside. In practice, it is found that the litmus should be brought to a decided but not to a deep blue. Now the further volume of the standard solution of carbonate of sodium employed is the measure of the sulphuric acid economically employed in the manure, and is therefore the measure of the sulphuric acid in solution.

It frequently happens on keeping that in 'superphosphate' a process of 'going back,' or reduction takes place, so that whilst a sample freshly prepared may contain, say 25 per cent. of *soluble* phosphate, it may contain after a time only 22 or 23 per cent. This sometimes gives rise to considerable disputes between buyers and sellers, and from the nature of the action the sellers' estimate must be always the highest. To avoid these disputes it is becoming the custom to express the amount of the 'reduced' phosphate in an analysis of superphosphate, and many methods have been proposed for the purpose of estimating it with accuracy. The point is to find some reagent which does not affect the undecomposed *coprolite* (that being the mineral now more especially considered). The best plan is that in which *oxalate* of ammonium is employed. The process is carried out as follows:—Take about 1½ gramme of the superphosphate, extract the soluble part with cold water, and afterwards with boiling water: wash the insoluble residue on the filter into a beaker, boil for about half an hour with oxalate of ammonium and about two drops of oxalic acid, so as to have a slight acid reaction (this is done in order to keep the phosphate of magnesium in solution). Then filter: the filtrate contains the phosphates of calcium and magnesium, and perhaps a little phosphate of iron and aluminum.

To the filtrate add tartaric acid, ammonia, and the magnesic mixture (described above), and estimate the phosphoric acid as tribasic phosphate of calcium [$Ca_3 (Po_4)_2$]; wash the insoluble residue on the filter into a beaker, boil for about one hour with sulphide of ammonium and a few drops of ammonia, filter, &c. To the filtrate add the magnesic mixture and calculate the results in the same manner as the reduced phosphates of calcium and magnesium. Oxalate of ammonium is used as being a perfectly neutral salt; it is altogether unlikely to decompose a perfectly mineralized substance like coprolite. As well known, the decomposition of gelatinous phosphate of calcium by oxalate of ammonium is a quantitative reaction which takes place at once, the only necessity for boiling being to assist the subsequent filtrations. Boiling for ten minutes is sufficient to effect the object, while the oxalate does not under these circumstances attack the coprolite to any extent.

The composition of superphosphates must necessarily vary to a great extent, and depends not only on the materials, but on the proportion of acid used for solution. The analysis on the opposite page, by Dr. ANDERSON ('Elements of Agricultural Chemistry'), illustrates the composition of some good samples made from different substances.

Superphosphates made from bones alone are generally distinguished by a large quantity of ammonia, and rather a low percentage of biphosphate of calcium. This is owing to the difficulty experienced in making the acid react in a satisfactory manner on bones, the phosphates being protected from its action by the large quantity of animal matter, which when moistened swells up, fills the pores, and prevents the ready access of the acid to the

	Bones alone	Bone Ash	Chiefly Coprolites	Mixtures, containing salts of Ammonia
Water . . .	7·74... 7·79	5·33... 10·40	5·90... 10·17	7·07... 18·
Organic matter and ammoniacal salts	17·83... 21·69	6·94... 4·92	5·10... 4·13	9·87... 13·
*Biphospht. of calcium	13·18... 9·87	*21·35... 23·09	*12·24... 13·75	*17·63... 12·
Insoluble phosphates	10·31... 21·17	5·92... 6·08	16·90... 0·17	12·60... 8·
Sulphate of calcium.	46·00... 35·30	56·16... 47·78	52·39... 62·62	49·77... 46·
Alkaline salts . .	1·46... 0·94	traces	2·47... 0·96	0·06... 1·
Sand. . . .	3·48... 3·24	3·30... 4·30	6·00... 8·20	3·00... 2·
	100·00...100·00	100·00...100·00	100·00...100·00	100·00...100·00
Nitrogen . . .	2·11... 3·01	0·23... 0·31	0·11... 0·57	1·28... 1·
*Equivalent to soluble phosphates	20·57... 15·39	33·33... 36·02	19·10... 21·43	27·50... 19·

interior of the fragments. Superphosphates from bone-ash, on the other hand, contain a mere trifle of ammonia, and, when well made, a very large quantity of biphosphate of calcium. Their quality differs very greatly, and depends of course on that of the bone-ash employed, which can rarely be obtained of quality sufficient to yield more than 30 or 35 per cent. of soluble phosphates.

Coprolites are seldom used alone for the manufacture of superphosphates, but are generally mixed with bone-ash and bone-dust. Mixtures containing salts of ammonia, flesh, blood, &c., are also largely manufactured, and some are now produced containing as much as 4 or 5 per cent. of ammonia, and the consumption of such articles is largely increasing.

The following analyses (ANDERSON) illustrate the composition of some inferior varieties of superphosphates, in the manufacture of which the quantity of sulphuric acid has been reduced, and consequently containing a smaller proportion of soluble phosphates. These manures are sold in the market for much more than they are really worth :—

Water	21·60	5·37	7·19
Organic matter and ammoniacal salts	11·62	13.91	8·80
Biphosphate of calcium	2·98	2·02	6·42
Insoluble phosphates	25·70	15·80	14·03
Sulphate of calcium	23·60	47·52	51·93
Alkaline salts	10·70	3·73	3·43
Sand	3·80	11·65	8·20
	100·00	100·00	100·00
Ammonia	1·32	0·59	0·33

Bones.—The manurial value of bones is dependent partly on their phosphates and partly on the nitrogen they yield. The following points should be attended to in estimating the value of a sample:—

I. *Determination of Water.*—A weighed quantity is dried in the water-oven, until the weight remains constant.

II. *Determination of the Total Amount of fixed Constituents.*—Introduce into a platinum crucible about 20 grains of the bone in a coarse powder; place the crucible in an oblique position over the gas or spirit-burner, and allow it to remain until the ash has become quite white; the burning bone should be turned over from time to time with a platinum wire; when cold, weigh the residue.

III. *Determination of the Amount of Sand.*—Digest about 20 grains (or the residue of II.) with dilute hydrochloric acid; throw on a filter; wash, dry, ignite, and weigh the residue.

IV. *Determination of Lime and Phosphoric Acid.*—To the filtrate from the sand (III.) add a few drops of ammonia, so as nearly to neutralize the liquor, then add oxalate of ammonium, boil, and then excess of acetate of ammonium; allow the precipitated oxalate of calcium to subside, then filter it off, convert it into sulphate, and weigh. To the filtrate from the oxalate of calcium add tartaric acid, and then ammonio-sulphate of magnesium, and well agitate; filter off, after standing for a day; wash the precipitate on the filter with ammoniacal water, dry, ignite, and weigh as pyrophosphate of magnesium. This method recommends itself by its extreme simplicity, though it is not absolutely accurate, as it takes no cognizance of the *magnesia*, which all bones contain; as, however, it exhibits the total quantity of phosphoric acid (the real fertilizing agent), it gives all the information required for estimating the manurial value of the sample.

V. *Determination of the Nitrogen.*—Ignite from 15 to 20 grains with soda-lime, precisely according to the method recommended for the analysis of ammoniacal salts. The result of the analysis will show the exact quantity of ammonia which the gelatine of the bone is capable of yielding by its decomposition.

VI. *Determination of the Amount of Carbonic Acid in Combination with Calcium, and perhaps Magnesium.*—This is effected by the method of FRESENIUS and WILL.

In estimating the value of a manure, the particular element required by the soil to which it is intended to apply it must be taken into account. 'Thus (observes ANDERSON), a farmer who finds that his soil wants *phosphates*, will look to the manure containing the largest quantity of that substance, and possibly not requiring *ammonia*, will not care to estimate at its full value any quantity of that substance which he may be compelled to take along with the former, but will look only to the source from which he can obtain it most cheaply. It may be as well, therefore, to point out that *ammonia* is most cheaply purchased in Peruvian guano, *insoluble phosphates* in coprolites, and *soluble phophates* in superphosphates made from bone-ash alone.'

The bones used in agriculture are chiefly those of cattle. The following composition of the bones of the cow represents very nearly that of a *genuine* sample: —

Organic matter (gelatine)	33·25
Phosphate of calcium	55·50
Phosphate of magnesium	3·00
Carbonate of calcium	3·75
Soda and common salt	3·50
Chloride of calcium	1·00
	100·00

But bones are met with in commerce in other forms, in which their organic matter has been extracted, either by boiling or by burning; the latter is very common in the form of the spent animal charcoal of the sugar refiners, which usually contains from 70 to 80 per cent. of phosphate of calcium. It was formerly considered that the efficacy of bones as a manure depends solely on the quantity of phosphate which they contain; but the benefit derived from the nitrogenous constituent, which in the soil eventually takes the form of ammonia, is now fully recognized. The gelatine or organic part of bones consists of—

Carbon	50·37
Hydrogen	6·33
Nitrogen	17·95
Oxygen	25·35
	100·00

So that, supposing this animal substance to be decomposed in the soil, the quantity of it in 100 lbs. of dry bone is sufficient to produce upwards of 6½ lbs. of ammonia, as much as is present in 20 lbs. of sal-ammoniac, or in 30 lbs. of crystallized sulphate of ammonium. LIEBIG has indeed advanced the opinion that the ammonia of the atmosphere will give nitrogen enough to the plant, provided the soil be sufficiently supplied with the *mineral matters* which it requires; but it is well known that the exhausting stiffening-liquor for calicoes—which in Manchester is largely made from bones by boiling them under pressure—has been applied as a liquid manure to grass lands with the greatest success. Some years ago, at the suggestion of the late Professor JOHNSTON, a series of experiments was made in Scotland to test the relative value of burnt and unburnt bones, and the general results were these :—

1st. That *whole* bones, under favourable conditions, seldom fail in raising an average crop of turnips.

2nd. That burnt bones, in equivalent quantity, do *not* always succeed in raising an average crop.

3rd. That when to the burnt bones a sufficiency of organic matter in the form of farm-yard manure was added, then burnt bones produced the usual effects of whole bones. The farmer's surest reliance will therefore be on entire bones, especially if there be a deficiency of organic matter in his soil.

MERCURY (Quicksilver).—Mercury is a metal which, at the ordinary temperature, is fluid, of a silver white colour, with a tinge of blue; very bright, tasteless, inodorous; specific gravity 13·568. It boils at about 600° Fahr., and may be distilled. Mercury is not very perceptibly acted upon by exposure to the air, but when adulterated by other metals, especially by tin, it becomes converted into a black powder, which yields oxygen when heated, the mercury being at the same time revived.

Mercury, as it is met with in commerce, is generally very pure, yet it is often adulterated with *lead, tin, bismuth*; sometimes also it contains *copper*. These impurities, however, are easily detected, because pure mercury does not adhere to glass, china, or other similar surfaces, and therefore, when thrown into a porcelain dish or saucer, the globules are spherical, and remain so when moved about; whilst if adulterated with any of the above-mentioned metals, the globules, instead of remaining spherical, adhere to the surface, or are dragged in oval or irregular masses, leaving a sort of *tail*, which indicates at once the presence of impurities in solution. Pure mercury, when poured into a glass tube closed at one end, presents a convex surface, whilst if it contains other metals in solution, the surface is either plane or concave. Mercury, which contains $\frac{1}{4000}$ of lead, has a plane surface when poured into a glass tube, and therefore this amalgam is often employed for thermometers and other instruments. The objection to the use of such an amalgam in thermometrical tubes of a small bore is, that the column of mercury moves with some difficulty, on account of the adhesion to the glass; and moreover, it often becomes divided into two or more portions, which remain hanging in the capillary tube, interfering with the correctness of the instrument; it is sometimes troublesome, or even impossible, to reunite these portions of the mercury in one unbroken column, even by imparting a rapid centrifugal motion to the instrument.

When the surface of mercury soon becomes dull or tarnished, or covered with a film, or with a black powder, or does not readily separate into round brilliant globules, it is not pure.

Mercury being completely volatilized by heat, distillation offers an easy means of separating it from the other metals with which it may be mixed. The distillation may be effected in a bent iron tube, or in an iron retort provided with a bent iron tube connected with a receiver, or in strong glass retorts, as used in the usual way for liquids; the impurities remain in the retort.

When mercury is distilled in a glass retort, it is advisable to mix with it about one-third or one-fourth of its weight of iron filings, and the neck of the retort should be connected with a receiver half full of water; the opening or extremity of the retort should be adjusted so as to reach the surface of the water without plunging into it. If the neck of the retort is too short, it may be lengthened by a glass tube or by a roll of paper.

M. Millon remarked, that the presence of certain metals, such as lead and tin, impede considerably the distilling of mercury; which is, on the contrary, accelerated by other metals, such as platinum. M. Barreswill has shown that this effect is due, in the first case, to a pellicle of oxide from the oxidizable metals, which, covering the surface of the mercury, prevents its volatilization. A layer of oil or of resin acts in the same way.

When the mercury contains arsenic or zinc, a portion of the zinc and the whole of the arsenic distil over with the mercury. In such a case, the mercury should be treated by dilute nitric acid, and the whole should be well shaken. The arsenic and zinc, and, in fact, all the metals which it contains, may be thus eliminated, except tin; in the latter case, hydrochloric acid may be used, and a gentle heat applied.

The presence of arsenic is detected in the above solution by passing a stream of sulphuretted hydrogen through it, collecting the precipitated sulphide on a filter, and examining it before the blow-pipe with soda upon charcoal. An odour of garlic is indicative of the presence of arsenic.

Mercury, Oxide of (*Red Oxide of Mercury, Nitric Oxide of Mercury, Precipitate per se*).—Oxide of mercury is ordinarily in the form of a crystalline powder of a red or orange-red colour, which becomes yellowish when reduced into very fine powder, very slightly soluble in water; the solution renders syrup of violets green. When heated, peroxide of mercury turns black, but it becomes red again on cooling. At 400° it is resolved into mercury, and oxygen is evolved.

Peroxide of mercury is sometimes adulterated with *red lead*, or with *brick-dust*. This fraud may be detected by heating a portion of it in a small German glass tube, closed at one end, until the peroxide of mercury is completely decomposed; a fused residuum of *protoxide of lead* will then be left, or, if brick-dust is present, it will remain unaltered in the tube; or a portion of the peroxide of mercury may be heated on charcoal before the blowpipe, when the lead or the brick-dust will be left on the charcoal, by which means the fraud may be at once detected.

Mercury, Chloride of (*Calomel, Aquila Alba, Mercurius Dulcis*).—Calomel is a compound of mercury and chlorine; white, inodorous, tasteless, semi-transparent, volatilizable by heat, but less readily than corrosive sublimate. When pulverized it has a pale yellow colour, but it becomes blackish or grey by exposure to solar light. It is almost insoluble in *cold* water, but is soluble in about 12,000 parts of boiling water.

Calomel is often adulterated, to a considerable extent, by an admixture of various white powders, such as *chalk, sulphate of barium, white lead,* and is sometimes contaminated by some *corrosive sublimate* carelessly left in it by insufficient washing; also by *common salt* and by *sal-ammoniac.*

As, however, calomel is completely volatilizable by heat, the fixed impurities may be readily detected and determined by igniting a given weight of the sample.

In order to ascertain the nature of the fixed impurities, the residuum left after ignition should be treated by dilute hydrochloric acid. If an insoluble residuum be left, it may consist of *sulphate of barium* or *of lead.* These are distinguished from each other by moistening the insoluble residuum with hydrosulphuret of ammonia, which will render it black if it consist of sulphate of lead, but which will leave it white if it consist of sulphate of barium. If, on treating the residuum by hydrochloric acid, an effervescence is produced, a carbonate is present, which may be *chalk* (carbonate of calcium), or *white lead* (carbonate of lead). The same test as above mentioned, namely hydrosulphuret of ammonia, will identify which it is, for if it be carbonate of lead, the residuum will turn back; and if it be carbonate of calcium it will remain white. Or, after having dissolved (with effervescence) the residuum left after ignition, in hydrochloric acid, a current of sulphuretted hydrogen passed through the solution will produce a black precipitate of sulphide of lead, if lead is present; and if the liquor filtered from this precipitate, or in which sulphuretted hydrogen failed in producing a precipitate, being first neutralized by ammonia, and then tested with oxalate of ammonium, yields a white precipitate, it is oxalate of ammonium, and the adulteration therefore was chalk.

The presence of *corrosive sublimate* is always an unintentional impurity resulting from carelessness, or neglect; the presence of this virulent poison is detected in calomel by pouring *cold* water on a given weight of the sample, and throwing the whole on a paper filter. The cold water dissolves the corrosive sublimate and filters through, whilst the calomel remains altogether on the filter. The filtrate, being now tested by solution of nitrate of silver, will produce a white precipitate of chloride of silver; or a black precipitate of sulphide of mercury, if tested by sulphretted hydrogen.

The presence of corrosive sublimate may also be detected by digesting the calomel in alcohol and adding caustic potash to the liquor. The corrosive sublimate (if any have dissolved) will then produce a yellow or reddish-brown precipitate of hydrate of oxide of mercury.

Mercury, Bichloride of (*Corrosive Sublimate*).—Corrosive sublimate is a compound of mercury and chlorine. It has a nauseous, disagreeable, and persisting metallic taste. It is generally met with in commerce in white, acicular, imperfectly crystallized masses, semi-transparent on the edges, convex, even, and shining on one side, concave, and full of small confused crystals on the other side; sometimes also in small detached crystals which slightly effloresce by exposure. It is a most virulent poison. The specific gravity of corrosive sublimate is 5·298.

Corrosive sublimate is generally pure. Exposed to a red-heat, it should liquefy and then volatilize entirely. At a less degree of temperature it volatilizes also without undergoing fusion. It should dissolve completely in sulphuric ether, and likewise in three parts of cold alcohol. It is totally soluble in water, and ether takes it up from its aqueous solution. If it contains any chloride of mercury (calomel), a residuum is left when dissolved in water, calomel being insoluble in that menstruum.

The aqueous solution of corrosive sublimate is decomposed and precipitated by lime-water, or by solution of potash in the form of a yellow precipitate, which precipitate should also be completely volatilizable by heat. Any residuum is an impurity, the amount of which may be directly ascertained by weighing.

MILK.—Milk is a peculiar and well known liquid secreted by mammiferous animals for the nourishment of their young. It consists, besides water, of organic substances destitute of nitrogen—*sugar* and *butter;* and of an organic substance containing nitrogen in considerable quantity—the *curd* or *casein.* It contains, moreover, inorganic or saline matter, partly soluble and partly insoluble in pure water.

The proportions of these several constituents vary in different animals. This appears in the following Table, which exhibits the composition of the milk of several animals in its ordinary state, according to the analyses of HENRY and CHEVALIER ('Johnston's Agricultural Chemistry'):—

	Woman	Cow	Ass	Goat	Ewe
Cheese	1·52	4·48	1·82	4·08	4·50
Butter	3·55	3·13	0·11	3·32	4·20
Milk sugar	6·50	4·77	6·08	5·28	5·00
Saline matter	0·45	0·60	0·34	0·58	0.68
Water	87·98	87·02	91·65	86·80	88·62
	100·00	100·00	100·00	100·00	100·00

The milk from the cow, the goat, and the ewe contains, according to this Table, much more cheesy matter than that of the woman or the ass. It is probably the similarity of asses' milk to that of the woman, together with its deficiency in butter, which from the most remote times has recommended it to invalids as a light and easily digested drink.

General characters of pure Cow's Milk.—The milk from the cow alone is the object of this article. Genuine cow's milk is of a white or slightly yellowish-white colour, opaque, heavier than water usually in the proportion of about 1·030 to 1·000. When newly taken from the animal, it is almost always distinctly alkaline. It speedily loses this character, however, when exposed to the air, and hence even new milk often exhibits a slight degree of acidity. When left at rest for a number of hours, it separates into two portions, throwing up the lighter part to the surface in the form of cream. If the whole milk or the cream alone be agitated in a proper vessel (a churn), the temperature of the liquid undergoes a slight increase, it becomes distinctly sour, and the fatty matter separates in the form of butter.

If a little acid, such as vinegar or diluted hydrochloric acid, be added to milk warmed to about 100° F., it immediately coagulates and separates into a solid and a liquid part—the curd and the whey. The same effect is produced by the addition of *rennet* or of sour milk, and it takes place naturally when milk is left to itself until it becomes sour. At a very low temperature, or when kept in a cool place, milk remains sweet for a considerable time. At the temperature of 60° F., it soon turns or acquires a sour taste, and at 70° or 80° it turns sour with still greater rapidity. If sour milk be gently warmed it undergoes fermentation, and may be made to yield an intoxicating liquor. By longer exposure to the air it gradually begins to putrify, becomes disagreeable to the taste, emits an unpleasant odour, and ceases to be a wholesome article of food.

The composition of milk is here given:—

Milk	Cream		Butter	Solid fat	1 Stearine
				Liquid fat	2 Butyrine 3 Oleine
			Butter-milk	Caseum Serum or whey	
	Skim milk		Matter coagulable	By rennet	4 Caseum
				By acetic acid	5 Zeiger or serai
		Whey or serum		Saccharine matter	6 Sugar of milk
				Azotized matter	7 Osmazome
			Salts	Soluble in alcohol	8 Alkaline and earthy lactates and phosphates
				Soluble in water, not in alcohol	9 Alkaline sulphates and phosphates
				Insoluble in water	10 Earthy and ferruginous phosphates

Milk is therefore essentially a mixture of cream and of skim-milk. The cream, which consists of butter and caseum, is lighter than the skimmed milk, which consists of caseum, sugar, sugar of milk, and various salts.

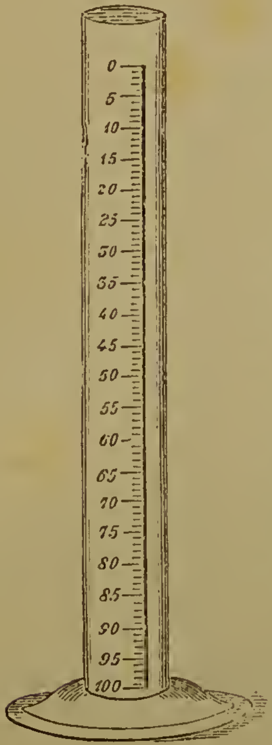
BERZELIUS gave the following analysis of skimmed milk:—

Water	928.75
Caseum and butter	26.00
Sugar of milk	35.00
Alcoholic extract and lactates	6.00
Chloride of potassium	1.70
Phosphate of alkali	0.25
Phosphate of lime, calcium combined with the caseum, magnesia, and traces of iron	2.30
	1000.00

As cream separates completely from milk after several hours' standing, the measurement of the quantity of cream given by it might therefore be taken as a criterion of the quality of the milk. For this purpose, an instrument called a '*galactometer*' is sold by philosophical instrument-makers, by means of which the quantity of cream contained in milk can be approximately estimated, the proportion of which of course represents the relative value of milk.

The galactometer is simply a large tube divided into 100 equal parts. The milk to be examined is poured into the tube up to 0, and the whole is left in a clean and cool place for 10 or 12 hours in summer, and from 15 to 16 in winter. At the end of that time the whole of the cream will have risen up, and the quantity per cent. of the cream contained in the milk is then determined by the number of degrees occupied by the cream.

Fig. 23.



The thickness or stratum of cream in pure milk is generally from 8 to 8⅕. If the milk submitted to experiment has been mixed, for example, with one-third of water, the quantity of cream produced will be reduced to 6½; if mixed with half water, 5; and if adulterated with two-thirds of its volume, the cream is only 3 per cent. of the bulk. Such an instrument may evidently prove useful to the consumer, but more especially so to the farmer, who may then ascertain the relative influence of various kinds of food on the quality of the milk given by his cattle, and consequently the relative value of his milch-cows.

The experiments of Boussingault and Lebel tended to show that the nature of the food on which cows are fed has not much influence on the quantity and quality of the milk. Dr. Voelcker has, however, conclusively proved that the amount and quality of the food exercises a most remarkable influence both on the quality and the compositions of the milk. In a valuable lecture recently (March 1874) delivered by that eminent agricultural chemist to the members of the Farmers' Club, he refers to a series of milk analyses made by him at Cirencester College, with a view of ascertaining what may be the variations in the course of a year in the quality of milk on one and the same farm. He took samples of the milkings of all the milch-cows and analyzed the mornings' and evenings' milk of the first or second day of each month. The cows were out at grass from May till the end of October, and as the herbage then became so scarce as not to afford sufficient nourishment, they were fed in the evening at the stall on roots, hay, &c. It will be seen by the appended analyses that both mornings' and evenings' milk in September were extremely poor. The poverty of this milk was therefore evidently due to an insufficient supply of food. The milk produced on two other farms in the neighbourhood during the same month, on being analyzed, was found to contain 12½ per cent. of solid matter, including 3½ per cent. of fat (pure butter), and the same percentage of curd; showing that on both farms where the cows were supplied with a sufficient amount of nitrogenous food the milk was of good quality, whereas on the college farm the scanty supply of poor grass had the effect of producing poor milk containing 96 per cent. of water and only 2 per cent. of fat. The influence of food on the quality of milk was also clearly visible in the cows of the College farm. On account of the insufficiency of the grass the ewes were driven into stall, and there supplied with roots, hay, and meal. The milk became better at once, for the mornings' yield then contained 12½ per cent. of solid matter, and in this nearly 4 per cent. of butter. The concentrated food which the cows received in the evening was evidently made into good rich milk during the night. At this time the cows were put on grass early in the morning, and allowed to pick up what they could. This was not much, as their anxiety in the evening to be let into their stalls clearly showed. The influence of a stinted supply of grass was noticed at once in the poverty of the evenings' milk. The percentage of solid matter fell to 9⅗ instead of 12½ per cent., and the butter to 3 instead of 4 per cent. Especial attention is directed to the fact that these analyses were not made from the milk of a single cow, but of the whole herd, and as the milch-cows were kept entirely for the use of the College there can be no question as to the genuineness of the supply.

'A great deal,' observes Dr. VOELCKER, 'has been said and written about milk adulterations—*sheeps' brains*, *starch*, *chalk*, and *pipe-clay*—which are said (on what authority nobody has ever decided) to have been found in milk, only exist in the imagination of the credulous or half-informed. It would be difficult to understand where all the sheeps' brains could come from; nor is it probable that chalk or other insoluble substances not easily kept in suspension should be employed in adulterating milk. Milk adulteration resolves itself into one of two things: either the addition of *water* or the abstraction of *cream*; and the question which naturally arises is, Can we detect to a nicety how much water has been added, or how much cream has been abstracted from a given sample?' Dr. VOELCKER expresses his strong opinion—the result of many years' experience—that owing to the natural variations in milk it is utterly impossible to ascertain whether in all cases a small quantity of cream has been removed from milk, or an inconsiderable proportion of water has been added to it; and he maintains that it is a reckless proceeding on

Composition of Morning and Evening Milk produced on the Agricultural College Farm, Cirencester.

		Percentage of					
		Water	Butter (pure fat)	Caseine and Albumen	Milk Sugar	Mineral Matters (Ash)	Nitrogen
January	Morning	87·76	2·6	2·94	5·82	·94	·47
	Evening	87·40	2·28	2·87	6·56	·89	·46
February	Morning	87·50	2·58	3·44	5·44	1·04	·55
	Evening	86·40	3·53	3·37	5·56	1·14	·54
March	Morning	88·60	2·71	2·43	5·35	·91	·39
	Evening	88·16	2·96	2·62	5·55	·77	·42
April	Morning	87·51	3·15	2·94	5·60	·81	·47
	Evening	89·00	2·47	2·69	5·08	·76	·43
May	Morning	88·20	2·42	3·12	5·49	·77	·50
	Evening	87·80	21·71	2·87	5·85	·77	·46
June	Morning	87·30	3·05	3·00	5·89	·76	·48
	Evening	87·30	2·94	2·87	6·05	·84	·46
July	Morning	88·70	2·22	2·94	5·38	·76	·47
	Evening	87·80	3·61	2·81	5·10	·68	·45
September	Morning	89·91	1·99	2·94	4·48	·64	·47
	Evening	90·70	1·79	2·81	4·84	·66	·45
October	Morning	87·60	3·00	2·87	4·84	·79	·47
	Evening	90·30	2·99	2·37	3·76	·88	·38
November	Morning	87·10	3·41	2·94	5·41	1·14	·47
	Evening	86·20	3·78	3·19	5·68	1·15	·51
December	Morning	86·70	3.74	2·87	5·92	·77	·46
	Evening	86·00	4·12	3·62	5·46	·80	·58

the part of any analyst to assert that milk has been adulterated with exactly 8 per cent. of water or with 13·75 per cent. of skimmed milk as in one case, or with 16·25 per cent. as in another. Such assertions can only be made by young and inexperienced men.

Although chemical analysis may do much in the way of revealing adulterations of food, and although there is no difficulty in discovering whether milk has been skimmed or watered to any great extent, all milk analyses should be conducted by persons upon whose practical experience and acquaintance with the subject reliance can be placed.

As the result of Dr. VOELCKER'S experience milk may be considered rich when it contains from 12 to 12½ per cent. of solid matter, 3 or 3½ of which are pure butter. If it contains more than 12½ per cent. of solid matter, and has 4 per cent. or more of fat, it is of extra rich quality. Such milk usually throws up from 11 to 12 per cent. of cream by bulk after standing for 12 hours at 62° F., and has a specific gravity varying from 1·028 to 1·030. Good milk of fair average quality contains from 10½ to 11 per cent. of dry matter, and in this about 2½ per cent. of pure fat. It yields 9 to 10 per cent. of cream, and has a specific gravity of of about 1·030. Poor milk contains 90 per cent. or more water, and has lower specific gravity than 1·027. Such milk yields not more than 6 to 8 per cent. of cream. Skimmed milk throws up still less cream, has a bluer colour, is more transparent, and when undiluted with water has a slightly higher specific gravity than new milk. Good skimmed milk has a specific gravity of 1·033, and poor skimmed milk 1·028 to 1·030. Milk purposely watered yields only 5 to 6 per cent. of cream, and invariably has a lower specific gravity than 1·025. If milk is both skimmed and watered, it yields less than 4 per cent. of cream, and possesses as low a specific gravity as 1·025 to 1·026. Specific gravity is within certain limits the most trustworthy indicator of quality. Cream is lighter than milk, but denser than water in the proportion of 1·012 or even 1·019 to 1·000. The addition of cream cannot, therefore, depress the specific gravity of milk in the same degree as the addition of water. A low specific gravity thus always indicates a large proportion of water. The results of some accurate gravity determinations of pure milk, milk after skimming, and milk purposely mixed with 10 to 50 per cent. of water, showed Dr. VOELCKER that good pure milk has a specific gravity of 1·030; skimmed milk a little higher; and that milk having a specific gravity as low as 1·025 is either very poor or has been mixed with water. If the gravity should sink to 1·023 or less, the milk has been mixed with a considerable quantity of water.

Separation and Estimation of the Constituents of Milk.—For many purposes a rough examination may be made as follows (JOHNSTON's 'Agricultural Chemistry'):—

1. If a weighed quantity of milk be allowed to stand for a sufficient length of time the cream will rise to the top, and may easily be skimmed off. If this cream be gently heated, the butter, in an oily form, will collect upon the surface, and when cold may be separated from the water beneath and its weight determined.

2. If the skimmed milk be gently warmed and a little vinegar or rennet then added to it, the curd will separate, and may be collected in a cloth, pressed, dried, and weighed.

3. If a second equal portion of the milk be weighed, and then evaporated to dryness by a gentle heat and then weighed, the loss will be the quantity of water which the milk contained.

4. If now the dried milk be burned in the air till all the combustible matter disappears, and the residue be weighed, the quantity of inorganic saline matter will be determined.

5. Suppose these processes to be performed with tolerable accuracy, the difference between the sum of the weight of the water, butter, curd, and ash, and the weight of the milk employed, will *nearly* represent that of the sugar combined in the given quantity of milk.

When, however, anything like an accurate analysis is required, the following method (HAIDLEN, 'Annal. der Chem. and Pharm.', vol. xiv. p. 263) may be adopted:—

(a.) *The Butter.*—The weighed quantity of milk is mixed with one-sixth of its weight of common unburnt gypsum, previously reduced to a very fine powder. The whole is then evaporated to dryness, with frequent stirring at the heat of boiling water. A brittle mass is obtained, which is reduced to fine powder. By digesting this powder in ether, the whole butter is dissolved out, and, by evaporating the ether, may be obtained in a pure state and weighed, or the powder itself, after being treated with ether, may be dried and weighed. The butter is then estimated by the loss.

(b.) *The Sugar.*—After the removal of the butter, alcohol is poured upon the powder and digested with it. This takes up the sugar with a little saline matter soluble in alcohol. By evaporating this solution and weighing the dry residue, the quantity of sugar is determined; or, as before, the powder itself may be dried and weighed, and the sugar estimated by the loss. If we wish to estimate the small quantity of inorganic saline matter which has been taken up along with the sugar, it may be done by burning the latter in the air and weighing the residue.

(c.) *The Saline Matter.*—A second weighed portion of the milk is now evaporated carefully to dryness, and again weighed. The loss is water. The dried milk is then burned in the air. The weight of the incombustible ash indicates the proportion of inorganic saline matter contained in the milk.

(d.) *The Casein.*—The weight of the butter, sugar, saline matter, and water, being thus known and added together, the deficiency is the weight of *casein.*

The following scheme for the analysis of milk has been kindly supplied for this work by its author, Dr. A. VOELCKER, F.R.S.:—

(a.) Weigh out 500 grains of milk, add a few drops of acetic acid, by which it is at once coagulated, and the operation of drying thereby facilitated.

(b.) Evaporate in a thin porcelain or platinum dish over the water-bath, at a low heat, and finally dry at 212° till the weight remains constant.

(c.) Thoroughly scrape the residue out of the dish, and reduce it to a fine powder; again dry at 212° on the water-bath to expel any water which the residue may have absorbed during the powdering. The weight of this residue should be from 55 to 60 grains.

(d.) Determine the amount of nitrogen in about 12 grains of the residue by combustion with soda-lime, and calculate the amount of nitrogen; this, multiplied by 6·25 grains, gives the amount of the nitrogenous constituents of the milk (*casein* and *albumen*.)

(e.) Take from 20 to 25 grains of the dry residue and exhaust with ether for the determination of the fat. This is best done by placing the powder in small separate portions between cotton-wool in an ether-extracting apparatus, consisting of a piece of glass tube such as is used for organic analyses, drawn out somewhat at one end, and passed air-tight through the cork of a small flask, A, which flask is connected with another similar flask, B, by means of a bent glass tube, as in the alkalimetrical apparatus of FRESENIUS and WILL, described in the article on *Alkalimetry.* If the powdered residue be divided in this matter between cotton wool, it does not clog, and the extraction of the fat is rapid. In the elongated end of the extracting tube a plug of cotton-wool is placed: this forms an efficient filter. About three-quarters of an ounce of ether is placed in flask A, which is then gently heated by placing it in some warm water; the ether vapour passes through the tubes and condenses in flask B, placed in a beaker of cold water. By removing the two flasks from the warm and the cold water, the ether runs back from B, and passes through the milk residue and cotton, and extracts the fat. This process is repeated three or four times, until a drop of ether, passing through the cotton, leaves no residue on evaporation in a watch-glass. Finally, the ether is distilled off into flask B for the greater part, and the solution of fat in ether in flask A is evaporated in a small weighed beaker and dried at 212°.

(f.) In the rest of the dry residue, the ash or mineral matter is determined by careful incineration in a small platinum dish.

These experiments give data for the determination of *water*, *casein*, and *ash*; the difference is the milk sugar. In another portion of milk the amount of cream is ascertained in the lactometer, and the specific gravity determined.

MINIUM. *See* RED LEAD.

MORTARS (HYDRAULIC). *See* LIME.

MUNJEET. *See* MADDER.

MURIATE OF AMMONIA. *See* SAL AMMONIAC.

MURIATIC ACID. *See* HYDROCHLORIC ACID.

MUSK.—Musk is a substance of a peculiar and well-known odour, secreted in a bag by the male musk-deer (*Moschus moschiferus,* a species of chevrotain belonging to the moschidæ, or musk tribe), closely resembling the deer in its general form and appearance, inhabiting the mountainous Kirgesian and Sangorian steppes of the Altai, on the river Irtysch, extending eastward as far as the river Jenesi and lake Baikal. It exists also in Mongolia, Thibet, and Butan, as far as Tonquin, and generally in the mountains of Eastern Asia, ranging between 30° and 60° of latitude. The musk is found, as above said, in a bag under the belly of the male animal, and consists of several superposed membranes externally covered by the skin and hair. Musk, as found in commerce, is solid and granular, of a peculiar, persisting, and well-known odour.

In trade, two distinct species of musk are known, which we shall distinguish as Musk *a,* comprising the Chinese, Tonquin, Thibetian, or Oriental musk; and Musk *b,* which includes the Siberian, Cabardinian, or Russian musk. These varieties—which for the sake of brevity we shall term, the one Russian and the other Chinese—differ materially both in the external appearance of the bag and the colour of the hair which covers it, as well as in their chemical and physical properties, and different effects on the human constitution.

It is generally supposed that these differences depend chiefly on the difference in climate which the animals inhabit, and partly is to be attributed to the difference in food which such variations in temperature occasion. By some, however, it has been premised, that to a difference in species may be attributed the differences of the drug. Dr. GOEBEL is of opinion rather that these different properties of Chinese musk, as compared with the Russian, should be mainly, if not entirely, attributed to the difference of treatment which they undergo in China, and he considers that the Chinese musk is the natural product after it has been subjected to the ingenious adulterations of the Chinese.

M. GUIBOURT (in his 'Histoire abrégée des Drogues Simples,' tome 2ieme, p. 744) has given the following qualitative analysis of Chinese musk, undertaken by himself and M. BLONDEAU : —

1, water; 2, ammonia; 3, solid fat (stearine); 4, liquid fat (elaine); 5, cholesterine; 6, acid oil, combined with ammonia; 7, volatile oil; 8–10, chlorides of ammonium of potassium and calcium; 11, an undetermined acid, partly saturated by the preceding bases; 12, gelatine; 13, albumen; 14, fibrine; 15, carbonaceous matter, soluble in water; 16, calcareous salt; 17, carbonate of calcium; 18, hairs and sand.

The quantity of water varies necessarily with the state of dryness of the musk; that examined by MM. Guibourt and Blondeau contained 0·46. The quantity of free ammonia, or that which is so feebly combined as to be disengaged by desiccation, varies in the same manner. The musk referred to contained 0·00325.

The solid and liquid fats were found to be identical with that of sheep and other ruminants; the cholesterine appeared similar to that of human biliary calculi.

The chief exportations of musk, from the London market, are directed to Hamburg, Rotterdam, and St. Petersburg.

Musk of an excellent quality is now imported from the United States free from carbonate of calcium.

The following are the characteristics of good musk:—It consists for the most part of round, oval, slightly flattened and sometimes irregular grains, the size of which varies from that of a pin's head to that of a pea, and concreted together, slightly unctuous. The colour of the grains is deep brown, almost black, with a reddish cast; when rubbed between the fingers the grains crumble, but no grittiness is felt.

The principal adulteration of this costly substance consists in mixing it with a portion of the *blood* of the animal, which, however, may be recognized by the larger size of the grains, which look like what in fact they are, namely, clots of blood—though it should be observed that the Chinese roll up the dried blood into pellets, which imitate the grains of genuine musk very closely. If, however, these grains be heated, a fetid vapour is evolved, which is not the case with genuine musk.

Asphaltum is another substance frequently used for adulterating musk, and also a kind of black brittle earth, sand, small pieces of lead, heavy spar, water.

Asphaltum is detected, because if a grain of the spurious musk be placed on the point of a knife and plunged into the flame of a candle, it will fuse and inflame; whilst genuine musk does not fuse, nor does it inflame; it only becomes charged.

Earthy matter, *sand*, and other impurities, may be easily separated, because genuine musk is soluble in sulphuric ether, and likewise in boiling water, either of which menstrua will leave the impurities in an insoluble state; in genuine musk only one-fourth of the weight is thus left undissolved.

Falsifications of any kind may further be detected, because all the pods or bags which have been tampered with exhibit marks of sewing or stitching, which shows that the bags have been opened for the introduction of the spurious substance. The

Chinese musk-bags, however, which invariably have been opened for that purpose, are sometimes closed up again, not by stitching, but by gluing the sides together; in which case, the fraud is much more difficult to detect by simple inspection. A genuine musk-bag, however, has two small openings, which are sometimes so contracted and narrow that they are not easily discovered, but whenever they are wanting, the pod is always spurious. The size of a genuine musk-bag varies from one to two and a half inches in diameter, and is more or less round. It is covered with stiff yellow or brownish-yellow hair, converging towards the centre. In those bags which have been obtained from old animals, the hair is less abundant, and appears as if worn out; it is also of a darker hue. This is a sign of some importance, because the goodness and value of the genuine article depends in a great measure upon its having been obtained from middle-aged animals; that procured from either too young or too old animals being of inferior quality. The presence of a large quantity of small round grains in the interior of the bag is also a sure sign of the goodness of the musk, and when viewed through a microscope no fibrous particles should be perceived. As we said before, the musk from Russia or Siberia is always pure, and sometimes so fresh, that when cut through moisture can be squeezed out, and the mass inside is soft and pappy.

The chemical tests of the purity of musk are the following:—It should dissolve in boiling water, and leave only one quarter of its weight in an insoluble state, and the boiling solution should be precipitated by acids, more particularly by nitric acid, so as to become almost colourless. Solution of acetate of lead, and that of galls, should likewise precipitate it; but one of corrosive sublimate should not create the slightest precipitate or turbidness.

The ashes of musk, after incineration, should not be red or yellow, but grey, neither should they exceed 5 or 6 per cent. The ashes consist of carbonate and sulphate of potassium, chloride of potassium, and phosphate of calcium, with traces of magnesia and of peroxide of iron.

MYROBALANS.—Myrobalans are the fruits of a species of plum-tree in East India, which are occasionally brought into this country in the dried state. The dried fruit is shrivelled up like prunes, has an olive colour and shape, an unpleasant, astringent, and sweetish taste. Myrobalans are used in India, and sometimes also here, either alone or mixed with galls, for making ink.

An aqueous extract of this fruit was some years ago brought to London, in large puncheons and hogsheads, and after having remained for several years a perfect lumber in the warehouse at the docks, spurned by all to whom it was offered for sale, and looked upon as a perfectly useless drug, it was at last put into the late Dr. Normandy's hands by the importer, for the purpose of ascertaining whether any use could be made of it. It was ascertained that this ill-received drug could produce a black dye and ink of surpassing depth and intensity of colour, *faster* than that obtained from the best blue galls, and of a more jetty hue. It was found also that with proper management, cotton could be dyed by it of a beautiful, fast, velvet-black colour. The ink made from it was better in point of colour, or at any rate, at least equal to that made from the best galls, and it resisted the action of chemical reagents incomparably better than that made in the usual manner. With alum the extract yielded a most durable olive green, also a brown colour of great beauty, on properly mordanted tissues. Experiments were also tried with it for tanning leather, and the result has been very satisfactory; though it should be remarked that the leather so tanned retained a dingy olive-green colour, which for certain purposes might be objectionable. This substance, the use of which is scarcely known in this country, or which is at least but seldom employed, might be advantageously substituted for galls for most purposes, and it is much cheaper. The value of the extract may be ascertained by gelatine, exactly as for catechu.

MYRRH.—Myrrh is a gum-resin, met with in commerce in angular pieces, and in grains, the largest of which do not exceed the size of a filbert.

The best myrrh is transparent, of a reddish-brown colour, easily broken, and its fracture exhibits waving lines, of a lighter colour than the mass. It has a strong, peculiar odour, and a bitter, acrid, aromatic flavour. The myrrh which comes from Abyssinia is sometimes so soft that it can be cut like tallow. RIGHINI gives the following test for ascertaining the merits of that substance:—Pulverize the myrrh, and leave it mixed for a quarter of an hour with its own weight of sal-ammoniac, also in powder; add now fifteen times its weight of water. If the mixture dissolves completely and rapidly, the myrrh is pure.

The incineration of genuine myrrh should not leave more than 3·6 or 3·8 of ashes, consisting of sulphate, phosphate, and carbonate of calcium, with a little carbonate and sulphate of potassium, and a trace of chloride of potassium.

NICKEL. *See* KUPFER-NICKEL.

NITRATE OF POTASSIUM (**Saltpetre, Nitre**).—*Nitrate of potassium*, more generally called *saltpetre* or *nitre*, is a salt of great commercial importance, which is found in abundance on the surface of the soil, principally in East India, Egypt, America, Italy, and Spain; it is obtained also by lixiviating certain soils called *nitre-beds.*

In France and in Germany *nitre-beds* are artificially made from old plaster rubbish, old mortar, and other calcareous earth, mixed with refuse animal and vegetable matter, which, putrefying in contact with the above calcareous salts, forms *nitrate of calcium.* The nitrate of calcium is afterwards converted into *nitrate of potassium* (saltpetre) by mixture with wood-ashes, and lixiviating the whole. For the particulars of this manufacture the reader is referred to DUMAS, 'Chimie appliquée aux Arts,' and to Dr. URE'S 'Dictionary of Arts, Manufactures, and Mines.'

The saltpetre consumed in England comes from East India, whence it is imported in the rough state, that is, in broken crystals, somewhat resembling bay-salt, of a brownish or greyish colour, and more or less deliquescent.

Pure nitrate of potassium is always an anhydrous salt, but its crystals ordinarily retain a small quantity of water of interposition, especially when the crystals are large. Its specific gravity is 1·933. It crystallizes in long striated six-sided prisms, generally terminated by diedral summits, and often contain longitudinal cavities internally. Nitrate of potassium sometimes crystallizes in rhomboedrons. Pure nitre is colourless and inodorous; its taste is at first fresh and cooling, and then somewhat pungent and bitter. It is not altered by exposure to the air, but it deliquesces in an atmosphere fully saturated with moisture.

According to M. GAY-LUSSAC, the solubility of nitre in water increases very considerably with the temperature, and in the following proportions:—

		Cent.		Fahr.			
100 parts of water at		0°	=	32°	dissolve	13·3	of nitre.
"	"	24	=	75·2	"	38·4	"
"	"	50·7	=	123·26	"	97·7	"
"	"	79·7	=	175·56	"	169·7	"
"	"	97·7	=	207·86	"	236·0	"

Sal prunella, or *crystal mineral,* is saltpetre which has been exposed to 600° Fahr., at which temperature nitre fuses without being decomposed, and forms, in cooling, a white compact mass, which is more easily pulverized than the crystals of nitre, and which is sometimes cast into balls or cakes.

The impurities contained in rough saltpetre are :—

Water.
Chloride of sodium (common salt) in various proportions.
Nitrate of sodium } Resulting from the reaction of
Chloride of potassium } common salt upon the nitre.
Sulphate of calcium, or of alkalies.
Traces of organic matter.

The determination of these impurities, or the loss which results from the purification or refining of nitre, is called refraction, and is sometimes attended with difficulties.

There are various methods of assaying saltpetre; but whichever process is adopted, great attention must be paid in the taking of samples, that they may represent, when mixed, a fair average of the quality of the article.

Valuation of Nitre.—1. *Method of Pelouze* ('Comptes rendus,' January 1847).—This is founded on the peroxidation of a protosalt of iron by the oxygen of the nitric acid, a solution of permanganate of potassium being employed, as in Marguerite's process (see *Iron*), to indicate the completion of the oxidation. The operation is as follows:—It is first accurately determined how much pure nitrate of potassium is requisite to peroxidize a known weight of iron dissolved in excess of hydrochloric acid. Pelouze found that 2 grammes of pure iron (pianoforte wire), dissolved in a considerable excess of hydrochloric acid, required from 1·212 to 1·220 gramme; on an average, therefore, 1·216 gramme of pure nitrate of potassium. He examined the nature of the gases given off in this reaction, and found them to consist of hydrochloric acid and binoxide of nitrogen. Converting these numbers into equivalents, they correspond to 6 equivalents of iron and 1 equivalent of nitrate of potassium: the acid of this last salt is decomposed, therefore, into binoxide of nitrogen, which is disengaged, and into 3 equivalents of oxygen, which deprive the hydrochloric acid of 3 equivalents of hydrogen to form 3 equivalents of water and liberate 3 equivalents of chlorine, which produce with the 6 equivalents of protochloride of iron 3 equivalents of perchloride. It will be observed, by the way, that this decomposition of nitrates by protosalts of iron in the presence of an excess of hydrochloric acid furnishes a method of preparing binoxide of nitrogen. This decomposition being established, it occurred to Pelouze that it might be made the basis of a ready and simple method of analyzing the nitrates. He found that the presence of sulphates and chlorides in no way interfered with the decomposition, in whatever proportion they were present; and there only therefore remained to be found a safe and ready method of determining, in the assay of an impure nitrate, the quantity of iron not peroxidized. Such a method has been described by MARGUERITE. Suppose, for instance, that, having operated upon 30·88 grains of iron and 18·77 grains of impure nitre, the permanganate of potassium indicates that 3·088 grains of iron have not been peroxidized, it may be concluded that 30·88 grains minus 3·088 grains, or 27·79 grains, have been peroxidized. Now, if the nitre had been pure, the whole 30·88 grains would have been peroxidized; we therefore have the proportion—

As 30·88 : 18·77 :: 27·79 : 16·89;

the 18·77 grains of impure nitre consequently contain 16·89 grains of nitrate of potassium, or 90 per cent.

The following example will illustrate the practical details of the method. The specimen may be supposed to be taken from a sample of the crude nitre of commerce as it is sent to the refiner:—

30·88 grains of pianoforte wire are placed in a flask of the capacity of about 10 cubic inches, and on them are poured about 1,500 grains of strong hydrochloric acid; the flask is closed with a cork furnished with a drawn-out tube, and the iron dissolved at a gentle heat. When the whole is dissolved, 18·52 grains of the nitre under examination are introduced, the flask is immediately closed, and the liquid boiled; it becomes of a brown colour; dense vapours of hydrochloric acid, mixed with binoxide of nitrogen, issue from the orifice of the drawn-out tube, and prevent the access of air. As soon as the liquid loses the brown colour, it becomes yellow, and gradually brightens: after boiling for five or six minutes, and when the liquid has become perfectly transparent, the flask is removed from the fire, the liquid which it contains, and the wash-water, are poured into a flask capable of holding about 60 cubic inches, which is then entirely filled with ordinary water: upon this a solution of permanganate of potassium of known strength is gradually added from a graduated burette. The operation is then finished, and there remains only to calculate the result.

Let us suppose that the solution of permanganate was of such a strength that 25 divisions of the burette were required to peroxidize 7·72 grains of iron, or 50 divisions for 15·44 grains of that metal; and let us further suppose that to complete the preceding experiment 10 divisions of the same solution were required; now, if 50 divisions of this permanganate suffice to peroxidize 20 of iron, how much ought 10 divisions to peroxidize?

As 50 : 15·44 :: 10 : 3·088.

3·088 therefore are subtracted from 30·88 grains of iron, and it may be concluded that the remaining 27·888 have been peroxidized by 18·52 grains of crude nitre; but it is known that 30·88 grains of iron represent 18·77 grains of pure nitrate of potassium, the quantity of that salt therefore corresponding to 27·888 grains of iron is found by the following proportion:—

As 30·88 : 18·77 :: 27·888 : 16·95.

In the 18·52 grains of saltpetre submitted to analysis there were therefore 16·95 grains of pure nitre = 91·4 per cent. In performing the experiment, the operator must be careful in guarding against access of air, otherwise this would be apt to act upon the binoxide of nitrogen, and render it capable of peroxidizing a further quantity of iron, so that the amount of nitre would be exaggerated. However, the peroxidation of iron, when the metal is dissolved in a strongly acid liquid, is very slow, as MARGUERITE has shown; and in the manner of conducting the process, as described above, the inconveience is avoided, for as soon as the iron has disappeared in the acid the flask is filled with hydrogen and hydrochloric acid gases: the nitrate which is introduced carries with it but a mere trace of air, and the liquid kept boiling disengages, by the drawn-out tube, acid and aqueous vapours, the issuing forth of which being always visible and readily maintained, does not allow the admission of any air.

PELOUZE states that he has confirmed the accuracy of his method by the analysis of several other nitrates, such as those of sodium, ammonium, lead, &c.; and he observes, further, that it will enable us to determine the amount of water in certain nitrates, the composition of which is at present doubtful.

This method has been subjected to an elaborate critical examination by ABEL and BLOXAM ('Quart. Jour. Chem. Soc.', vol. ix. p. 97). They have arrived at the conclusion that, although the reaction upon which it is founded is perfectly correct, and that therefore it frequently happens that the most accurate results are furnished by it, nevertheless these results are liable to contain disturbing causes, which are so far beyond the control of the operator as to deprive the method of that certainty so essential to any process in use for commercial analysis. These disturbing causes are—1. The action of air upon the nitric oxide gas, by which nitric acid is regenerated. 2. The incomplete expulsion of the nitric oxide from the fluid, in consequence of which it reduces a larger quantity of permanganate of potassium than corresponds with the amount of protoxide of iron contained in it; this, however, is only to be feared in dilute solutions. 3. The evolution of nitric acid *before* it has acted upon the protochloride of iron, especially when the fluid boils very rapidly after the addition of the nitrate, and when the excess of protochloride of iron is proportionally small. All these sources of error may, according to Fresenius (Liebig's 'Annalen,' May 1858, p. 217), be avoided, and perfectly satisfactory results obtained, by the following method of operating:—Into the belly of a tubulated long-necked retort, capable of containing about 200 cubic centimètres, so fixed that the neck is directed a little obliquely upwards, is put about 1·5 gramme of fine pianoforte wire, accurately weighed, and from 20 to 40 cubic centimètres of *pure* fuming hydrochloric acid are added. Hydrogen gas, washed in a solution of potash, is now passed in through the tubulure by means of a glass tube reaching about two centimètres into the retort, and the neck of the retort is united to a U-shaped tube containing a little water. The belly of the retort is placed on the water-bath, and gently heated, till the iron is completely dissolved. It is then allowed to cool in the current of hydrogen, which is afterwards strengthened, and the nitrate, weighed in a small tube, is thrown in with the tube through the neck of the retort. The quantity of the nitrate should be calculated, so that it may only contain about 0·200 gramme of nitric acid. After the union of the neck of the retort with the U tube, the contents of the retort are heated on the water-bath for about a quarter of an hour, the water-bath is then removed, and heat is applied by a lamp so as to produce strong ebullition, until the solution, which has a dark colour from the absorbed nitric oxide gas, has acquired the colour of perchloride of iron; after reaching this point, the boiling is continued for a few minutes. Every time the fluid is agitated, care must be taken that dry salt is never deposited on the walls of the retort. Before the boiling is stopped, the current of hydrogen gas is strengthened, in order to prevent the entrance of air through the U tube when the lamp is removed. The retort is allowed to cool in the current of hydrogen, the contents are much diluted with water, and finally the iron, still existing as *protoxide*, is determined with solution of permanganate of potassium.

This method may, according to the author, be employed with the greatest confidence when no organic matters are present.

Instead of estimating the amount of protoxide of iron on which the nitric acid has not acted by permanganate of potassium, Braun ('Journ. für Prakt. Chem.', lxxxi. 421) determines the amount of peroxide formed by means of iodide of potassium and hyposulphite of sodium. The perchloride of iron decomposes the iodide of potassium, and sets the iodine at liberty, even in the cold, but more completely when the reaction is assisted by a gentle heat. The free iodine is estimated by a normal solution of the hyposulphite, after having added a small quantity of starch paste. The normal solution of hyposulphite of sodium is prepared either by dissolving a known weight of the salt in a similarly known weight of water, or by standardizing with a solution of hyposulphite of unknown strength the iodine set free by perchloride of iron prepared from a known weight of metallic iron.

II. *Gay-Lussac's method, modified by Abel and Bloxam.*—The nitrate is converted into carbonate by fusion with charcoal, and the amount of alkaline carbonate is determined by a standard solution of sulphuric acid. In order to moderate the evolution of nitrogen gas, a certain quantity of pure common salt is added to the mixture. The proportions usually employed are 1 part of lamp-black, 4 of nitre, and 24 of salt, to 20 of nitre. The nitre and charcoal are first mixed in a platinum crucible with a glass rod, the chloride of sodium is then added, and an intimate mixture of the whole is made. The crucible is covered and heated, cautiously at first, to prevent too violent deflagration, and afterwards for a few minutes at a red temperature; when cold, the contents of the crucible are washed into a flask, treated with hot water, the residual carbon filtered off, and the alkalinity of the solution then determined by a normal solution of sulphuric acid.

ABEL and BLOXAM, who have thoroughly investigated this method, likewise ('Quart. Journ. Chem. Soc.', vol. ix. p. 110, and vol. x. p. 107) employ an acid so far diluted that a little less than 1,000 grain-measures are required to neutralize the amount of carbonate of potassium, corresponding to 20 grains of nitre. An acid of this description contains from 8·0 to 8·5 grains of anhydrous acid in 1,000 grain-measures. The strength of the acid having been approximately ascertained by the neutralization of a known weight of carbonate of sodium, is finally determined with the greatest possible accuracy by precipitation as sulphate of barium. In performing the alkalimetrical assay, a sufficient quantity of aqueous solution of litmus is added to impart a deep blue colour to the liquid; the standard acid is then added until it acquires a wine-red tint from the dissolved carbonic acid; the liquid is then boiled, and the acid very carefully added, drop by drop, until the peculiar *onion-skin red* colour imparted by the stronger acids to litmus is obtained. The accurate appreciation of the colour is much facilitated by using, as a standard of comparison, a similar quantity of coloured water to which a few drops of sulphuric acid have been added.

A great number of experiments made by ABEL and BLOXAM disclosed a considerable uncertainty in the above method. This they traced to the following facts:—1. That a considerable quantity of nitre may escape decomposition at a high temperature, even when intimately mixed with an excess of finely divided carbon, and although vivid deflagration of another portion of the nitre had taken place in its immediate neighbourhood. 2. That in the deflagration of a mixture of nitre, salt, and charcoal, *binoxide of nitrogen* is evolved in large quantity. 3. That in the deflagration, *cyanide of potassium* is formed; and that, even where much care had been taken to remove moisture from the materials, a notable quantity of *ammonia* is evolved. 4. That the oxidation of cyanide of potassium, by exposure to the air at a high temperature, is not prevented by the presence of carbon in a finely divided state, or even by covering it with a layer of carbon. By substituting pure, ignited, and finely divided graphite for charcoal, in the conversion of the nitrate into carbonate of potassium, and by the subsequent treatment of the fused mass with chlorate of potassium in order to oxidize the cyanate of potassium formed by the oxidation of the cyanide of potassium, and to obviate the errors which may arise from the reduction of any sulphates which may be present, ABEL and BLOXAM succeeded in obtaining very accurate results. The proportions they recommend are 20 grains of nitre, 5 grains of ignited graphite, and 80 grains of pure common salt. The crucible, covered with a jacket, should be loosely covered, and moderately heated for two or three minutes over the gauze gas-burner; it should then be allowed to cool to such an extent that chlorate of potassium shall not fuse when sprinkled upon the mass. About 25 grains of the chlorate are added, so as to form a layer upon the surface. A very gentle heat is first applied, until most of the chlorate has been decomposed, when the temperature is raised to bright redness, and maintained in that state for two or three minutes; when cool, the mass is to be carefully shaken out of the crucible into a funnel, and the crucible and cover washed with boiling water. The mass is dissolved by a stream of hot water from a washing-bottle, and the solution allowed to run into the flask in which the determination is to be made; the liquid is coloured with litmus, and neutralized with the standard acid.

NITRATE OF SILVER. *See* SILVER.

NITRATE OF SODIUM (**Nitre Cubic**).—*Cubic nitre*, or *Chili saltpetre*, is the commercial name of nitrate of sodium, which is found in a native state, in extensive deposits under a thin stratum of clay, on the boundary coasts between Peru and Chili.

Nitrate of sodium being hygroscopic, cannot be used in the manufacture of gunpowder; but nitrate of potassium is sometimes made from it, in countries where potash is cheap, by treating the nitrate of sodium by carbonate of potassium or chloride of potassium. The nitrate of sodium and chloride of potassium being first dissolved in boiling water, and mixed together in the proper proportions, chloride of sodium, being the less soluble salt, falls first, and nitrate of potassium remains in the liquor, from which it is deposited in crystals on cooling.

The principal use of nitrate of sodium, however, is for the manufacture of nitric acid, by decomposing it with sulphuric acid; and as a source of nitric acid in the manufacture of sulphuric acid. It is also employed as a manure.

The nitrate of sodium of commerce is met with in the form of a moist, dirty, brownish mass, containing, when not adulterated, generally more than 95 per cent. of the salt, and frequently only a mere fraction of chloride of sodium or other impurities.

The mode of ascertaining the commercial value of nitrate of sodium is exactly the same as for nitrate of potassium.

NITRE. *See* NITRATE OF POTASSIUM.

NITRE (CUBIC). *See* NITRATE OF SODIUM.

NITRIC ACID (Azotic Acid, Aquafortis).—Nitric acid is a compound of nitrogen and oxygen. The most concentrated acid contains 14 per cent. of water. The density of nitric acid diminishes in proportion to its state of dilution.

The specific gravity of commercial nitric acid is generally 1·31, but it is sometimes met with as high as 1·513, which corresponds to 85·7 per cent. of real acid, in which state it is a colourless liquid, of a strong, disagreeable, suffocating odour; its taste is excessively acid and corrosive; it emits white, irritating fumes in the air, but when diluted it does not fume; it rapidly destroys organic substances, and stains them yellow. The commercial concentrated acid has generally a yellowish colour. When the acid is known to be pure, its strength may be determined by taking its specific gravity. The Table on next page, by Dr. URE, shows the strength of the acid corresponding with its density.

The specific gravity of nitric acid is sometimes artificially augmented by dissolving *nitrate of potassium* in it; this sophistication, however, is very easily detected by evaporating the acid, when the nitrate so added will be left behind. But the best way of ascertaining the real value of nitric acid is by determining its saturating power, as has been indicated in the article on *Acidimetry*.

The nitric acid of commerce is frequently contaminated by *sulphuric* and *hydrochloric acids*, or by *chlorine* or *chlorides*.

Specific Gravity	Liquid Acid in 100	Dry Acid in 100	Specific Gravity	Liquid Acid in 100	Dry Acid in 100
1·5000	100	79·700	1·2947	50	39·850
1·4980	99	78·903	1·2887	49	39·053
1·4960	98	78·106	1·2826	48	38·256
1·4940	97	77·309	1·2765	47	37·459
1·4910	96	76·512	1·2705	46	36·662
1·4880	95	75·715	1·2644	45	35·865
1·4850	94	74·918	1·2583	44	35·068
1·4820	93	74·121	1·2523	43	34·271
1·4790	92	73·324	1·2462	42	33·474
1·4760	91	72·527	1·2402	41	32·677
1·4730	90	71·730	1·2341	40	31·380
1·4700	89	70·933	1·2277	39	31·083
1·4670	88	70·136	1·2212	38	30·286
1·4640	87	69·339	1·2148	37	29·489
1·4600	86	68·542	1·2084	36	28·692
1·4570	85	67·745	1·2019	35	27·895
1·4530	84	66·948	1·1958	34	27·098
1·4500	83	66·155	1·1895	33	26·301
1·4460	82	65·354	1·1833	32	25·504
1·4424	81	64·557	1·1770	31	24·707
1·4385	80	63·760	1·1709	30	23·900
1·4346	79	62·963	1·1648	29	23·113
1·4306	78	62·166	1·1587	28	22·316
1·4269	77	61·369	1·1526	27	21·519
1·4228	76	60·572	1·1465	26	20·722
1·4189	75	59·775	1·1403	25	19·925
1·4147	74	58·978	1·1345	24	19·128
1·4107	73	58·181	1·1286	23	18·331
1·4065	72	57·384	1·1227	22	17·534
1·4023	71	56·587	1·1168	21	16·737
1·3978	70	55·790	1·1109	20	15·940
1·3945	69	54·993	1·1051	19	15·143
1·3882	68	54·196	1·0993	18	14·346
1·3833	67	53·399	1·0935	17	13·549
1·3783	66	52·602	1·0878	16	12·752
1·3732	65	51·805	1·0821	15	11·955
1·3681	64	51·068	1·0764	14	11·158
1·3630	63	50·211	1·0708	13	10·361
1·3579	62	49·414	1·0651	12	9·564
1·3529	61	48·617	1·0595	11	8·767
1·3477	60	47·820	1·0540	10	7·970
1·3427	59	47·023	1·0485	9	7·173
1·3376	58	46·226	1·0430	8	6·376
1·3323	57	45.429	1·0375	7	5·579
1·3270	56	44·632	1·0320	6	4·782
1·3216	55	43·835	1·0267	5	3·985
1·3163	54	43·038	1·0212	4	3·188
1·3110	53	42·241	1·0159	3	2·391
1·3056	52	41·444	1·0106	2	1·594
1·3001	51	40·647	1·0053	1	0·797

The presence of sulphuric acid is detected by evaporating about two ounces of the acid in a platinum dish till it is reduced to about two drachms, then with pure water, and adding a solution of nitrate of barium; if this produces a white precipitate, insoluble in water, in acids, and likewise in ammonia, it is sulphate of barium, and it indicates, of course, the presence of *sulphuric acid.* If the precipitate is in ponderable quantities, it should be first boiled with the acid liquor in which it has been produced, allowed to settle, filtered, washed, dried, ignited, and weighed. 117 grains of sulphate of barium represent 40 of dry sulphuric acid, or each grain of sulphate of barium represents 0·34368 grain of dry sulphuric acid.

The presence of *chlorine*, or of *chlorides*, or of *hydrochloric acid*, is detected by diluting the nitric acid with pure water, and adding a solution of nitrate of silver. If a white, curdy precipitate, or an opaline tinge, or turbidness is produced, insoluble in nitric acid, but which immediately disappears by pouring an excess of ammonia, and reappears by adding an excess of acid, it is chloride of silver; in which case the acid liquor should be moderately heated, in order to promote the settling of the precipitate, which may then be collected on a filter, as small as possible, washed, and carefully dried. It should then be introduced into a counterpoised porcelain crucible; the filter being scraped clean, is then burnt upon the cover of the crucible, and the ashes are added to the precipitate in the crucible; the mass is then fused, and after cooling, it is weighed. 145 grains of chloride of silver represent 35.5 grains of chlorine, or 36·5 grains of hydrochloric acid; or each grain of fused chloride of silver represents 0·24729 grain of chlorine, or 0·25427 grain of hydrochloric acid.

Before testing the acid do not omit to dilute it with three or four times its bulk of distilled water, for otherwise a precipitate would be produced, but which is nothing else than nitrate of barium and nitrate of silver, which might simulate the presence of sulphuric acid and of chlorine. Such precipitates, however, immediately disappear by an addition of water.

When nitric acid contains fixed substances, they are easily detected by evaporating a small quantity of the acid in a watch-glass or small capsule, in which case a fixed residuum will be left. Pure nitric acid is entirely volatilizable by heat.

Impure nitric acid can always be easily purified by adding to it a sufficient quantity of nitrate of silver, in order to precipitate the chlorine and sulphuric acid, decanting the acid from the precipitates produced, and distilling it in a glass retort and glass receiver, taking care not to use either lute or cork. If done with care, and at a moderate heat, the acid which passes over is perfectly white.

OILS.—There are two kinds of oils. (a.) The *fixed oils*, which, as their name implies, do not sensibly evaporate at the ordinary temperature, and which do not distil at the temperature of boiling water; such oils have only a faint odour, similar to that of the substances from which they have been extracted, and have scarcely any taste, at least when fresh. Their gravity is less than water, and ranges between 0·913 and 0·936. They permanently stain paper and render it translucid.

(b.) The *volatile or essential oils*, which are entirely dissimiliar both in properties and composition. When distilled with water they pass over at 212°, or when distilled by themselves at or under about 320° Fahr. They have a caustic, hot, acrid taste, and an aromatic odour. Their specific gravity ranges between 0·847 and 1·096.

Fixed Oils and Fats.—These are most indispensable requisites of domestic economy; equally important for nourishment, as materials for the manufacture of soap, and as sources of light. *Fats* are not homogeneous chemical combinations, but mixtures of such which, taken singly, have all the properties of fats themselves. By congelation at low temperatures and pressure of the concrete mass a separation of the fat ensues into a liquid and a solid portion. The former consists of *olein* and the latter of *stearin* or *margarin*, or a mixture of both.

By pressure between folds of blotting-paper or in linen bags a nearly complete separation of the *olein* takes place, and the solid *stearin* or *margarin* remains. By heating the paper in water the liquid olein may be obtained separate.

Enumeration of Vegetal Greasy Oils (MUSPRATT'S 'Chemical Dictionary').

Name	Plants yielding the Oil	Specific Gravity
Olive-oil	Olea Europæ	0·9176
Rapeseed-oil	Brassica campestris et Napus	0·9136
Colza-oil	Brassica campestris oleifera	0·9136
Summer rape-seed-oil	Brassica præcox	0·9390
Almond-oil	Amygdalus communis	0·9180
Cocoanut-oil	Cocos nucifera	
Palm-oil	Cocos butyracea vel Avoira elais	0·9680
Tee-loil	Sesamum orientale	
Oil of bin	Guilandina mohringa	

Enumeration of Vegetal Greasy Oils—(continued).

Name	Plants yielding the Oil	Specific Gravity
Beech-oil	Fagus silvatica	0·9225
Oil of mustard	Synapis nigra et arvensis	0·9160
Plum-kernel-oil	Prunus domestica	0·9127
Butter of cocoa	Theobroma cocao	0·8920
Laurel-oil	Laurus nobilis	
Ground nut-oil	Arachis hypogea	0·9242
Piney tallow	Vateria Indica	0·9260
Oil of radish seed	Raphanus sativus oleifera	0·9189
Cherrystone-oil	Prunus malus	0·9237
Apple-seed-oil	Pyrus cerasus	
Spindle-tree-oil	Euonymus Europæus	0·9389
Cornel-berry-tree-oil	Cornus sanguinea	
Oil of the roots of cyper grass	Cyperus esculenta	0·9180
Henbane-seed-oil	Hyoscyamus niger	0·9130
Horse-chestnut-oil	Æsculus Hippocastanus	0·9270

Drying Oils.—These oils differ from those just enumerated by their property of becoming gradually converted into solid masses by exposure to the atmosphere, and also by not being solidified by contact with nitrous acid or protonitrate of mercury. Their principal use is in the preparation of varnishes and painters' colours, and the more quickly they become hard by exposure the more valuable they are for these purposes. Their seccative properties may be much increased by heating them with about 7 or 8 per cent. of their weight of *litharge*, which in this proportion is for the most part dissolved by the oil.

Enumeration of Drying Oils.

Name	Plants yielding the Oil	Specific Gravity
Linseed oil	Linum usitatissimum et perenne	0·9347
Nut-oil	Corylus avellana et Juglans regia	6·0220
Poppy-oil	Papaver somniferum	0·9243
Hempseed-oil	Cannabis sativa	0·9276
Castor-oil	Ricinus communis.	0·9611
Grapeseed-oil	Vitis vinifera.	0·9202
Cucumber-oil	Cucurbita Pepo et Mepepo	0·9231
Sunflower-oil	Helianthus annuus et perennis	0·9262

Enumeration of Drying Oils—(continued).

Name	Plants yielding the Oil	Specific Gravity
Tobacco-seed-oil	Nicotiana Tabacum et rustica	0·9232
Oil of julieure	Hesperis matronalis . . .	0·9281
Oil of camelina	Myagrum sativa	0·9252
Oil of weld-seed	Reseda luteola	0·9258
Oil of cress-seed	Lepidium sativum . . .	0·9240
Oil of deadly nightshade .	Atropa belladonna	0·9500
Oil of cotton-seed	Gossypium barbadense . .	
Pinetop-oil . .	Pinus abies	0·9285

According to Mr. HEIDENRREICH, of Strasburg, the purity of the fixed oils of commerce may be approximately determined, and the admixture of cheaper oils detected, in the following manner:—

(1.) *By observing the peculiar odour of the oil when gently heated.*

For this purpose, a few drops of the oil under examination should be poured into a small porcelain or platinum capsule, and exposed to the heat of a spirit-lamp. The odour which is evolved, immediately suggests that of the plant or of the animal from which it has been obtained, and this characteristic is valuable more especially if observed in conjunction with the genuine oil, and furnishes accurate indications of the presence of linseed-oil, whale-oil, train-oil, or rape-oil, in any mixture. M. PENOT, however, observes that the odour of the oil is not always a safe criterion, since an oil of the same fruit or nut has not always the same odour. This is especially the case with olive-oil, the odour of which differs according to the different places where it has been grown. The same is the case with other oils, if cold drawn, or if expressed under the influence of heat.

(2.) *By the action of concentrated sulphuric acid.*

'By mixing a small quantity of concentrated sulphuric acid with some oil (in proportion of about 1 or 2 parts of the former to 100 parts of oil), very intense action immediately ensues, the temperature increases, and the mixture becomes coloured.

'A plate of white glass being laid over a sheet of white paper, if we place on the former from 10 to 15 drops of oil, and then add thereto one small drop of sulphuric acid of 66° = 1·632 specific gravity, a colour will soon be produced without stirring, differing according to the oil employed.

'In the case of *rape-oil* there will gradually form, at a certain distance from the drop of sulphuric acid, a greenish-blue ring, whilst towards the centre, where the action is more violent, light yellow-brown streaks may be observed.

'*The expressed oil of black mustard-seed* likewise assumes a tinge of bluish-green; but the quantity of oil must, in this case, be increased to 25 or 30 drops.

'In *train-oil*, obtained from the whale or stock-fish, a very peculiar motion occurs, commencing at the centre and extending to the outside, whilst a red colour is observed, which grows more and more vivid, until after ten or fifteen minutes, when the margin assumes a violet tinge, which, in the course of about two hours, becomes uniform throughout the mixture.

'*Olive-oil* instantly assumes a pale yellow colour, which afterwards becomes a yellowish-green.

'In *poppy-oil*, and that obtained from sweet almonds, the colour approaches to that of the greenfinch, and afterwards becomes of a dead yellow hue.

'In *linseed-oil*, a drop of acid produces a beautiful dark brownish-red web, which is gradually converted into a brownish black.

'*Tallow-oil* (called by the trade oleic acid) is rendered brown.

'If, instead of allowing the sulphuric acid to act on the oil undisturbed, both fluids be stirred up with a glass rod after adding the drop of sulphuric acid, the phenomena mentioned appear in different order.

'*Rape-oil* then assumes a uniform brown colour, without a tinge of red; and if, instead of one drop of acid, five or six are added, and mixed with the oil, the whole mass becomes of a dead brown-red colour, not very intense, remaining green only on the edges.

'By doubling or trebling the expressed oil of black mustard-seed, the quantity tested gives rise to a similar action, with the exception that the colour is somewhat less bright.

'*Train-oil* instantly assumes, when stirred, a lively brown-red colour, which finally passes to dark brown and violet, without a hue of green. If mixed with five or six drops of acid, the colour is much more intense, and tho violet colour sooner appears.

'*Seal-oil* assumes a yellowish-gray colour. If, however, thirty drops of oil are taken instead of ten, a colour slightly approaching to green-blue also appears, so that one drop more changes it into gray. On the addition of five or six drops of acid, it receives a lively orange-yellow tint.

'The oils from the olive, poppy, and sweet almonds, all assume a yellow colour more or less dingy or gray; and by the addition of more acid the action is rendered far more violent.

'If *linseed-oil* is stirred with the rod, as before mentioned, a brownish-black lump forms, and by adding five or six drops of acid the whole forms a resinous, black, and persistent mass. It is true that all other oils likewise become plastic by the addition of greater or smaller quantities of acid; none, however, to a similar degree, and with a colour so black, as linseed-oil. The oil obtained from tallow assumes a dark, dirty brown colour, which does not vary in tint by the addition of more acid.

'In trade it seldom occurs that a better oil is mixed with an inferior one. Oil of almonds, olives, and codfish-oil, will therefore never be used for adulterating rape-oil, but probably train, or perhaps linseed-oil, and sometimes poppy-oil. If we are led, therefore, by the odour, to infer an adulteration—for instance, by train-oil, which occurs the most frequently—it is only necessary to place from ten to fifteen drops of rape-oil, the purity of which is undoubted, together with as much train-oil, and an equal quantity of the oil whose purity is suspected, and to add to each of them a small drop of sulphuric acid. From the colour produced an inference may be drawn as to the purity of the oil, and by the difference of tinges from the vivid red of the train-oil, and the bluish-green of rape-oil, the extent of adulteration may be ascertained.

'In undertaking an experiment, the commencement of the reaction must be accurately observed, with the several oils placed beside each other; for the colours, after a quarter of an hour has elapsed, are less distinct, and the mixture should, for the purpose of attaining to greater certainty in the first experiment, be left undisturbed; in a second experiment it is stirred with the glass rod. It is likewise necessary to avoid employing more than one drop of the acid to ten drops of oil, since otherwise the reaction which ensues is too violent.

'If the presence of linseed-oil be suspected in train-oil, this will be discovered, if the mass is left undisturbed, by a rather intense brownish-red colour; if disturbed, by a brownish-black colour.

'The adulteration by poppy-oil is seldom met with in commercial rape-oil, because it is commonly much dearer than the latter. Sometimes, however, the reverse is the case, and rape-oil is found adulterated with poppy-oil. In this case the colour produced is of a very slight bluish-green, approaching somewhat to yellow, but not sufficiently distinct to admit of an inference being drawn, as to the adulteration, with perfect certainty. In such cases the specific gravity of both oils must be received as the sole criterion for identifying them.

'It has been reported that tallow-oil has several times been mixed at Paris with rapeseed-oil; beside the brownish colour produced by sulphuric acid, the tallowy smell, the brown colour, the acid reaction, and last although not least, its density, which is less than any other of the fixed oils, are such decisive characteristics, that we must be blind indeed if we do not instantly discover this fraud.'

Instead of 10 or 15 drops of oil M. PENOT directs to employ 20 drops, &c.

'M. PENOT, in a report on the preceding researches of M. HEIDENREICH, made in the name of the chemical *Comité de la Société Industrielle de Mühlhausen*, makes the following additional remarks to the three means suggested by M. HEIDENREICH, for discovering the adulteration of oils.

'1. As regards the detection of adulteration by the *odour of an oil*, it must be observed that the same oil—that is to say, an oil of the same fruit or nut—has not always the same odour. This is especially the case with olive-oil, the odour of which differs according to the different places where it has been grown. The same is the case with other oils, if cold, drawn, or expressed under the influence of heat.

'2. As regards the action of sulphuric acid, M. PENOT directs us to employ 20 drops of oil, which he places on capsules of white porcelain. He likewise found that every different kind of oil indicated a different reaction, which, however, did not entirely agree with the results obtained by M. HEIDENREICH. Besides this, M. PENOT employed a saturated solution of chromate of potassium in sulphuric acid, always in the proportion of 1 drop to 20 drops of oil, which were stirred together. The following Table shows the difference of the reactions produced by both reagents on twenty different kinds of oil. It is, however, necessary, in order to insure greater certainty, that we should first compare the effects of them on a pure oil, when any oil is suspected of having been adulterated, since it is difficult to remember precisely the colours produced by reagents, and still more difficult to convey such a definition as will be understood by every one.

'By perusing this Table (M. PENOT continues) it will be observed that the same oil does not, under any circumstances, yield precisely similar results with the same reagent. This depends on the place of their growth, their age, and the manner of pressing. If, however, any oil be examined comparatively with a perfectly

Action of One Drop of the Reagent on Twenty Drops of Oil.

Name of the Oil	Sulphuric Acid		Solution of Bi-chromate of Potassium
	Not Stirred	Stirred	
Oleic acid	Reddish spots with reddish circles	Reddish-brown	Reddish-brown
Oil of sweet almonds	Greenfinch-yellow with orange spots	Dirty-green	Yellowish small lumps
Whale train-oil	Reddish small lumps on a brown ground	Lees of wine	Brownish-red small lumps on a brown ground
Hemp-oil	Brown small lumps on a yellow ground	Greenish-brown	Yellow small lumps on a green ground
Rapeseed-oil	Scarcely perceptible spots	Green	Yellow small lumps on a ground coloured green by the chrome
Liver train-oil	Dark-red	Dark-red	Dark-red
Linseed-oil from the Upper Rhine	Dark reddish-brown	Brown small lumps on a gray ground	Brown small lumps on an almost colourless ground
Linseed-oil from Paris	Reddish-brown, less dark-coloured	Clotted brown on a green ground	Brown small lumps on a ground coloured green by the chrome
Madia sativa	Slightly reddish-brown underneath a thin layer (film), approaching to gray	Olive-green	Light-brown small lumps on an olive-coloured ground
Rapeseed-oil, one year old, pressed out after exposing the seeds to a gentle heat	Green	Bluish-green	Yellow small lumps on a chrome-green ground
Rapeseed-oil, one year old, pressed out, at a somewhat higher temperature, from another factory	Green	Bluish-green	Yellow small lumps, more numerous, on a dirty-green ground
Rapeseed-oil, fresh	Green	Bluish-green	Yellow small lumps on a ground coloured green by the chrome
Nut-oil	Yellowish-brown	Clotted, dark-brown	Small brown lumps
Nut-oil, one year old	Yellow	Dirty-brown, less dark-coloured	Small brown lumps
Nut-oil, one year old, from another factory	Orange-yellow	Dirty-brown	Small brown lumps
Olive-oil, from Beaucaire	Slightly yellow	Dirty-brown	Olive brown
Olive-oil	Orange-yellow	Brownish-gray	Brown
Olive-oil, expressed by engine from fermented olives	Orange-yellow	Brownish-gray	Brown
Poppy-oil, fresh, cold drawn	Yellow spots	Brownish olive-coloured	Small yellow lumps on a white ground
Poppy-oil, one year old, expressed at a slight heat	Greenish spots	Slightly green	Small yellow lumps on a green ground
Neatsfoot-oil	Yellow slight spots	Dirty-brown	Brown spots on a brown ground
Castor-oil, native	Yellow slight spots	Almost colourless	Slightly green

pure one, the proof of adulteration may be rendered, if not certain, at least probable, by noting the difference. Thus I obtained, by adding 1 part of either whale-, train-, or linseed-oil, or oleic-oil, to 10 parts of rape-seed oil, the following results: —

Name of the Oil	Sulphuric Acid		Solution of Bichromate of Potassium
	Not Stirred	Stirred	
Rapeseed-oil with whale-train	More red ground than with rapeseed-oil	Brownish-olive coloured	Small reddish lumps on a gray ground
Rapeseed-oil with linseed-oil	No perceptible difference from the rapeseed-oil	Olive-coloured	Small and more numerous red lumps on a very dark-green ground
Rapeseed-oil with oleic-oil	No perceptible difference from the rapeseed-oil	Greenish-brown ..	Small brownish lumps on an olive-coloured ground

'The adulteration being ascertained as far as is possible, the oil is then tested by endeavouring to discover the adulterating oil, either by reagents, or by its odour when gently heated, as before described. This having been found out, small quantities of the suspected oil are added to a perfectly pure oil of the kind under examination. Every mixture is then tested by the reagents, until precisely similar results are obtained as those yielded by the oil under examination. Thus the proportions of the two mixed oils will be discovered by approximation.

'3. *The Density of Oils.*—Every oil supposed to come from the same plant, or the same animal, has its peculiar density, which, at the same temperature, never can deviate more than some few thousandths.

'This density is, in oils hitherto examined, between 0·900 [tallow-oil] and 0·96 [castor oil—Ricinus-oil]; water, at 15° C. = 59° F. taken as unity. This answers, on the centigrade alcoholometer of GAY-LUSSAC, to the densities from the 66th degree to the 34th. For greater perspicuity I have added the Table arranged by SCHUBLER, together with the degrees of GAY-LUSSAC'S alcoholometer. We deemed it best to add the latter, since it is very generally used, and saves employing other instruments. It is only necessary to procure a scale, the degrees of which are at proper distances. Besides this, an oil-balance could easily be arranged, on the same principle, by placing, at the temperature of 15° = 59° F., the number 0·970 as the extreme point at one end of the scale, or a little higher than the density of castor-oil, and for the extreme density of oleic acid ·900, and dividing the intervals between these into 70°, in such a manner that each degree answers to a thousandth part on the Table of densities.

Table of the Specific Gravity of some Oils.

Name	Specific Gravity	Degrees on Gay-Lussac's Alcoholometer	Degrees on Fischer's Oil-balance
Tallow-oil	0·9003	66	
Rapeseed-oil (Navette) (Brass. napus oleifera Dec.) .	0·9128	60$\frac{3}{4}$	37 to 38 Purified 38 to 39
Rapeseed-oil (Colza) Brass. campest. oleif.) . .	0·9136	60$\frac{1}{5}$	
Summer rapeseed oil (levatte) (Brass. præcox Decandolle	0·9139	60	
Olive-oil	0·9176	58$\frac{2}{5}$	37 to 38
Beechnut-oil	0·9225	56	
Purified whale-train . . .	0·9231	95$\frac{4}{5}$	
Poppy-oil	0·9243	55$\frac{1}{4}$	32 to 33
Dötter-oil (caméline) Myagrum (sativum) . .	0·9252	54$\frac{3}{4}$	31 to 32
Linseed-oil	0·9347	50	29 to 30
Castor-oil	0·9911	33$\frac{3}{4}$	
Oil of sweet almonds . . .	0·932		
Codfish-oil	0·923		
Filberts (oil of)	0·916		
Hempseed-oil	0·926		
Walnuts (oil of)	0·923		
Oil of madia sativa . . .	0·935		
" " " . . .	0·928		

'By examining this Table we find, as regards the different commercial oils, especially those commonly used for adulteration, an obvious difference of density: thus, for instance, the different rapeseed-oils weigh at 15° between 60$\frac{3}{5}$ and 60° according to the alcoholometer, whilst beechnut-oil weighs 56°; fish-train, 55$\frac{4}{5}$°; poppy-oil, 55$\frac{1}{4}$; dötter-oil (caméline), 54$\frac{3}{4}$°; and linseed-oil, 50°. In cases, therefore, in which rapeseed-oil indicated less than 60°, it might be inferred with certainty that it had been mixed with another oil. The same would be the case with olive-oil, if indicating more or less than 58$\frac{1}{2}$. It is true that the knowledge of the density of an oil does not precisely indicate by what oil the adulteration may have been performed; but, in this case, we can recur to the odour which the oil evolved when exposed to heat, and to the comparative experiments, previously mentioned, with sulphuric acid. The oil which has been employed for adulteration having been ascertained, the alcoholometer shows with certainty to what degree the adulteration extends.

'This latter means of examination has indeed already been employed by some in the trade; and I am astonished that it is not more generally applied, since it is a sufficiently good guide alone, and, if combined with the two others, I doubt if any one could be deceived.'

M. Penot thinks, however, that oils of the same name, but not identical, never have the same density.

The editor of the 'Journal f. Prakt. Chemie' remarks, that he has not found, in the course of his own experience, any difference in the specific gravity in oils of the same kind obtained from different places and grown in different years; and that in Saxony an areometer (or oleometer) is generally used for testing oils, constructed by the instrument-maker Fischer, of Leipzig, which indicates the specific gravity of oils in such manner, that pure rapeseed oil is indicated by 37° to 38°; and hemp-oil by 30° to 31°, &c. This oil-balance is very correct and useful. Another assistance in such examinations is the capillarimeter, an instrument for indicating the quantity of each oil which falls from a certain sized point under given circumstances.'

When *oil of almonds* is mixed with oil of poppies, the taste is sometimes sufficient to detect the presence of the latter oil; and if such an oil be agitated in a phial, it produces bubbles of air, which stick to the sides of the phial, which is never the case with pure oil of sweet almonds.

Oil, or *buttter of cocoa*, is always solid at the ordinary temperature, of a yellowish-white colour; its fracture is clean, and it has a soft, agreeable flavour, and a peculiar odour. It fuses at 77° Fahr.

When *butter of cocoa* has been well prepared, it may be kept for two or three years without becoming rancid; but that which is met in trade being often adulterated with tallow, or veal or mutton suet, very soon turns bad; but this fraud is generally perceptible, because, in that case, the flavour of the spurious article is not agreeable, like that of the genuine oil, and it leaves afterwards in the mouth a taste of tallow, which cannot be mistaken; the odour of tallow is easily recognised by heating it as directed by M. Heidenreich.

But of all these oils, the dearest (except oil of almonds), and consequently that which is most subject to adulteration, is *olive-oil*; and the oils with which it is most generally mixed are those of nuts and of poppies. The latter, more especially, is employed for the purpose, because it may be mixed in considerable proportion with olive-oil without materially altering the taste of the latter, whilst its price is only half that of olive-oil.

As with oil of almonds, when pure olive-oil is shaken in a flask or phial, its surface remains even, but if mixed with oil of poppies, it becomes covered with small air-bubbles.

When pure olive-oil is immersed in pounded ice, it becomes completely solidified, but if it is adulterated with oil of poppies, it solidifies only in part; and if the latter oil forms more than one-third of the bulk, the oil does not become solid at all.

M. POUTET recommends the following method for the detection of oil of poppies in olive oil, namely: dissolve six parts of mercury in seven and a half parts of nitric acid of sp. gr. 1·35; heat need not be applied; mix two parts of this solution with 96 parts of the oil under examination, and shake the mixture every half hour, or oftener. If the oil is pure, the mixture, after seven hours in summer, or three or four hours in winter, will have congealed into a thick magma, and in twenty-four hours it will have so far solidified that some little force must be employed to sink a glass rod through it. The other edible oils do not combine with nitrate of mercury, and if the olive oil contains some other oil, it thickens, but never becomes solid. If the quantity of foreign oil forms more than one-eighth of the bulk, it separates from the thickened mass into a distinct layer. The compactness of the mass, therefore, is proportionate to the quantity of the foreign oil. If the olive-oil contains its own bulk of another oil, one-half of the mixture is solid, and the other half is liquid. A temperature of about 90° Fahr. is the best for the experiment, for the oil and coagulum separate then perfectly from each other. If the oil has been adulterated with animal fat, the mixture will coagulate in five hours; in this case the coagulation consists of the animal fat, whilst the olive-oil floats on the surface, and may be decanted. If the coagulum or solidified portion be then heated, it exhales the odour of melted tallow.

M. BOUDET has shown that, in M. POUTET's method above related, it is not the nitrate of mercury, but the hypo-nitrous acid contained in the test-liquor which solidifies the olive-oil; and he found that one half-grain of hyponitrous acid, mixed with three times its own weight of nitric acid, was capable of solidifying 100 grains of olive-oil in about 78 minutes.

The fixed oils which may be solidified, when treated in the above manner, are those of sweet almonds, of filberts, and of colza; but the drying oils, except castor-oil, are not solidified by that treatment. Each of these oils requires different lengths of time to become solid, as shown in the following Table, in which 100 parts of the oils mentioned were treated by a mixture of nine parts of nitric and one of hyponitrous acid:—

Oils	Colours developed by the addition of the mixture	Number of minutes necessary to solidify oils	Proportions
Olive-oil . . .	Greenish-blue . . .	73	10·0
Oil of sweet almonds .	Dingy-white . . .	160	22·2
„ filberts . .	Greenish-blue . .	103	14·0
„ acajou . .	Lemon-yellow . .	40	6·0
„ Ricini (castor-oil)	Golden-yellow . .	603	82·6
„ Colza . . .	Yellowish-brown . .	2400	328·0

The presence of the oil of poppies may be easily recognised by its retarding effect; 1 per cent. of oil of poppies retards the solidifying at least 40 minutes.

Olive-oil is sometimes adulterated with *honey*; this sophistication may be recognised by treating the oil with hot water, which dissolves the honey; after shaking the mixture well it should be left at rest; the oil then separates from the water which has dissolved the honey. The oil may then be decanted, and by evaporation the honey is left behind.

The presence of *fish-oil* is readily detected in vegetable oils, by passing chlorine through them; in which case the mixture turns black.

Besides the tests above described, an instrument called the elaïometer was contrived by M. GOBBY, by which the purity of olive-oil may be estimated. The elaïometer is constructed on the principle of the hydrometer, but as the differences of density are inconsiderable, the bulb of the instrument is very large, and the tube or stem is very narrow. The instrument at 54·5° Fahr. marks 0° in poppy-seed oil, and 50° in pure olive-oil. The *modus operandi* is as follows:—The oil to be tested is first brought to a temperature of 54·5° Fahr., which is readily accomplished by plunging the glass cylinder containing it into cold water, or else the result of the operation may be corrected, if the temperature be above 54·5° Fahr., by deducting 2 from the degree indicated by the elaïometer for each degree of temperature, and if the temperature be lower than 54·5°, by adding 2 for every degree below 54·5° Fahr.

For example, let us suppose that the temperature at the time of the experiment is 60° Fahr., and the elaïometer indicates 61°,

Then 60·0° Temperature at the time of the experiment.
54·5 Normal temperature.
5·5° Difference.

Density indicated by the elaïometer . . . 61·0°
The difference 5·5 × 2 = ... 11·0
Real density . . . 50·0

The oil therefore is pure.

Or, let us suppose that the temperature observed at the time of the experiment is 52°, and that the elaïometer indicates 45·0°.

54·5° Normal temperature.
52·0 Temperature at the time of the experiment.
2·5 Difference.

Density indicated by the elaïometer . . . 45·0°
The difference 2·5 × 2 = ... 5·0
Real density . . . 50·0

The real density being 50, the oil is called pure.

General Table of

Oils	Caustic Soda, Sp. Gr. 1·340	Sulphuric Acid, Sp. Gr. 1·475	Sulphuric Acid, Sp. Gr. 1·530	Sulphuric Acid, Sp. Gr. 1·635	Nitric Acid, Sp. Gr. 1·180	Nitric Acid, Sp. Gr. 1·220
Olive ..	Slight yellow	Green tinge	Greenish-white	Light-green	Greenish ..	Greenish ..
Gallipoli	Ditto	Ditto	Gray	Brown	Ditto	Ditto ......
India nut	Thick and white	—	Dirty-white	Light-brown	—	—
Pale rape-seed	Dirty yellowish-white	—	Pink	Brown	—	—
Poppy..	Ditto	—	Dirty-white	—	—	Yellowish-red
French nut	Ditto	Brownish ..	Gray	Brown	Yellow	Red ......
Sesame	Ditto	Green tinge	Greenish dirty-white	—	Orange yellow	Ditto ......
Castor..	White	—	Dirty-white	—	—	—
Hemp-seed	Thick brownish-yellow	Intense green	Intense green	Intense green	Dirty-green	Greenish dirty-brown
Linseed	Fluid yellow	Green	Dirty-green	Green	Yellow	Yellow ....
Lard ..	Pinkish-white	Dirty-white	Dirty-white	Light-brown	—	—
Neats-foot	Dirty yellowish-white	Yellow tinge	Brownish dirty-white	Brown	Light-yellow	Light-yellow
Sperm..	Dark-red ..	Light-red ..	Red	Intense brown	Slight yellow	Ditto ......
Seal....	Ditto	Ditto	Ditto	Ditto	Pink	Light-red ..
Cod-liver	Ditto	Purple	Purple	Ditto	—	—

The degrees of the elaïometer are as follows:—

Pure olive oil	. . . . . .			50 degrees.
Olive oil mixed with	4	per cent. of oil of poppies		48 ”
” ”	10	”	”	45 ”
” ”	14	”	”	43 ”
” ”	20	”	”	40 ”
” ”	30	”	”	35 ”
” ”	40	”	”	30 ”

The admixture of *fish-oil* with animal or vegetal oils may be readily detected by the brown or black hue produced by the action of a stream of chlorine, and also, according to CALVERT, by the reddish coloration developed by boiling a mixture of the oil with solution of caustic soda.

Reactions.—(CALVERT.)

Nitric Acid, Sp. Gr. 1·330	+ Caustic Soda, Sp. Gr. 1·340	Phosphoric Acid, Syrupy	Sulphuric Acid + Nitric Acid	Aqua Regia	+ Caustic Soda, Sp. Gr. 1·340
Greenish ..	Fluid white mass	Slight green	Orange-yellow	—	Fluid white mass
Ditto ……	Fibrous white mass	Ditto ……	Dark-brown	—	Fibrous yellowish-white mass
—	Ditto ……	—	Orange-white	—	Fibrous white mass
—	Fluid white mass	—	Dark-brown	—	Fibrous yellowish-white mass
Red ……	Light-red fluid mass	—	Slight yellow	—	Fluid intense rose-coloured mass
Dark-red ..	Fibrous red mass	Brown-yellow	Dark-brown	Yellow ….	Fibrous orange mass
Ditto ……	Fluid red mass, with brown liquor beneath	—	Green, becoming intense red	Ditto ……	Fluid orange mass, with brown liquor beneath
—	Fibrous white mass	—	Brownish-red	—	Fibrous pale rose-coloured mass
Greenish dirty-brown	Fibrous light-brown mass	Green ….	Green, becoming black	Green ….	Fibrous light-brown mass
Green, becoming brown	Fluid yellow mass	Brown yellow-green	Ditto ……	Greenish-yellow	Fluid orange mass
Very slight yellow	Fluid mass	—	Brown ….	—	Fluid pink mass
Light-brown	Fibrous white mass	—	Dark-brown	Slight yellow	Fibrous brownish-yellow mass
Red ……	Fluid mass	Dark-red ..	Ditto ……	Ditto ……	Fluid orange-yellow mass
Ditto ……	Ditto ……	Ditto ……	Ditto ……	Ditto ……	Ditto
Ditto ……	Ditto ……	Ditto ……	Ditto ……	Yellow ….	Ditto

For the detection of a mixture of a siccative with a non-drying oil several methods may be applied—that e.g., of Poutet, which consists in the application of protonitrate of mercury, by which the *non-drying* oils yield *elaidin*, or that of Boudet, which depends upon the same reaction, to produce which, however, *nitrous acid* is substituted for the mercury salt: or that of Maunene, who showed that the non-drying oils give rise to a much higher temperature when mixed with strong sulphuric acid, than is the case with those belonging to the class of siccatives.

The preceding Table constructed by Calvert indicates the reactions afforded by a systematic method for testing the purity of oils by the employment of caustic alkali, and of various acids at different degrees of dilutions as well as mixtures of acids, and of acids and alkalies successively applied.

Essential Oils.—The essential oils of commerce are often adulterated with *fixed* or *fat oils*, *spermaceti*, *rosin*, *tallow*, *balsam of copaiba*, and *essential oils* of less value than the genuine oil.

The methods of detecting these fraudulent additions consist in pouring a drop of the essential oil upon a piece of paper, and evaporating it by heat. If the essential oil is pure, it will completely evaporate, and leave no stain on the paper; but if adulterated with either a fixed or fat oil, tallow, spermaceti, rosin, or balsam, a greasy stain will be left on the paper, which will then appear transparent at that part.

Alcohol is detected by putting a few pieces of fused chloride of calcium into a flask with the essential oil under examination, and shaking the whole well. If the essential oil be pure, the pieces of fused chloride of calcium will remain unaltered; but if alcohol is present, they will dissolve and form a heavy liquid, over which the pure essence will float in a distinct stratum. The proportion of alcohol, however, may be too small to dissolve entirely the pieces of chloride of calcium, but if alcohol be present they will always show that they have been acted upon, their edges will be more or less rounded, which would not be the case if the essence was pure.

The presence of alcohol mixed with an essential oil is almost readily detected, because the addition of water immediately produces a milkiness.

According to M. Biral, the presence of alcohol in essential oils may also be detected by means of potassium, as follows:—Pour twelve drops of the oil in a watch-glass perfectly dry, and add a piece of potassium about the size of a pin's head. If the piece of potassium remains in the middle of the oil for twelve or fifteen minutes, it is a sign that the oil does not contain alcohol;

but if, on the contrary, the potassium disappears in the course of five minutes, it is a sign that the oil contains more than 4 per cent. of alcohol, and if it disappears in less than one minute the oil contains 25 per cent. of alcohol, or more.

The addition of alcohol to essential oils is a most usual adulteration.

As to the addition of cheaper essential oils to the genuine article, the fraud is best detected as follows:—

Pour a few drops of the essential oil under examination upon a piece of blotting-paper, and allow it to evaporate spontaneously. The difference of the smell towards the end will often enable the operator to detect the sophistication. *Essence of turpentine* is generally employed for the purpose. In that case it may be separated by adding alcohol of specific gravity 0·84 (54·8 per cent. over proof), to the essential oil. The turpentine will be left in an insoluble state.

The specific gravity affords also another means of ascertaining the purity of essential oils. We therefore give here the specific gravity of the principal essential oils.

Essential Oil of	Amber . . .	0·868
” ”	Aneth . . .	0·881
” ”	Aniseed . . .	0·9857
” ”	Bergamot . .	0·888
” ”	Cajeput . . .	0·9274
” ”	Carraway . .	0·940
” ”	Cassia . . .	0·832
” ”	Cinnamon . .	0·975 to 1·043
” ”	Cloves . . .	1·036
” ”	Cumin . . .	0·975
” ”	Fennel . . .	0·029 to 0·997
” ”	Fusel (or of grain) .	0·833
” ”	Juniper . . .	0·911
” ”	Lavender . .	0·898
” ”	Do. rectified .	0·877
” ”	Lemon . . .	0·847
” ”	Mint . . .	0·898
” ”	Nutmeg . . .	0·948
” ”	Otto of roses . .	0·832
” ”	Rosemary . .	0·911
” ”	Sassafras . .	1·094
” ”	Turpentino . .	0·870
” ”	Wormwood . .	0·907

When the specific gravity of an essential oil is sufficiently different from that with which it is mixed, they may be separated from each other by agitating them for a long time with water, and leaving the whole at rest. The two oils will then separate in the order of their respective density.

The oil of *spic lavender* met with in commerce is seldom pure, and is generally a mixture of three parts of essence of turpentine with one of genuine oil of lavender. This fraud may best be detected by pouring a few drops of the suspected oil on a piece of paper and evaporating it; or else by pouring a drop of it on the back of the hand and rubbing it with the finger; when evaporated the persisting smell of turpentine will be recognised.

The oil of *neroli* is generally adulterated with alcohol, or with oil of *petit grain.*

The presence of alcohol may be detected in the manner above related, but that of oil of *petit grain* is more difficultly recognised, and the suspected article had better be compared, by evaporation of a drop on the back of the hand, with the genuine oil.

Otto of roses is often adulterated with oil of Rhodes, which oil has an odour of roses, but otto of roses which has been mixed with that oil loses its butyrous consistence.

The 'Chemical Times' for August 25, 1849, published the following remarks by Mr. GUIBOURT on the 'means of determining the purity of the otto of roses.'

'The high price of this article renders it a matter of great importance to be enabled to decide upon its purity. The following means, if used in combination, will leave no doubt upon this point:—

'The physical characters can be but little depended upon; thus, the yellow colour with a tinge of green, and its point of congelation, may be readily imitated. Its odour also is so powerful that a certain quantity of any other oil of a somewhat similar odour might be added without sensibly diminishing that of the otto. The manner in which it crystallizes is of a certain amount of importance. When, after having been liquefied by a gentle heat, it is allowed to cool slowly and at rest, it remains as it were transparent, in consequence of the thinness and the perfect transparence of its long and pointed crystals, which resemble the blades of daggers; and, on varying their position as regards the light, these laminæ reflect all the prismatic colours. When the otto of roses has been adulterated with any uncrystallizable oil, which requires that its property of congealing should be imparted by the addition of spermaceti, it presents, when solidified, a number of fine needles, which, however, are not transparent, but render the mass uniformly semi-opaque. But for this test to be of any value, the otto must be allowed to crystallize slowly and remain at rest; otherwise it becomes nebulous and opaque, like that which has been adulterated.

'The oil most frequently used for its adulteration is that of several species of pelargonium. The oils derived from the different species cannot be all identical, since M. RECLUZ has described one which is solid, whilst that which is met with in commerce is always liquid. The oil which I employed for comparison is called oil of geranium, and came from Nice. I also examined some oil of rosewood, which was distilled at Paris some years ago, and some of that found in commerce. Three reagents will serve to distinguish the pure otto—iodine, nitrous acid vapour, and sulphuric acid.

'*Test with Iodine.*—A small quantity of iodine is placed in a small glass vessel with a wide mouth; around it watch-glasses are arranged, each containing one or two drops of the oil under examination, and the whole is covered with a glass bell. At the end of a few hours the vapour of the iodine is found to have condensed upon every part of the interior of the glass bell, and upon the glasses containing the oils; but the margin of the watch-glasses containing the substituted oil is much more coloured than that of the glass containing the otto; and, when the former oils become brown, the latter retains its natural colour. After some hours the vessel containing the iodine may be removed; and then, the effect still continuing, the otto remains white, whilst the other oils become perfectly black. On exposing the watch-glasses to the air, the iodine which has condensed upon the margin of those containing the otto is volatilized, and the glass becomes almost colourless, whilst the others retain their black colour. I am satisfied that this test will serve, not only to determine the nature of the otto of roses, but also whether any oil of geranium or rosewood is present in it or not.

'*Nitrous Acid Test.*—For this I use a small glass vessel, placed upon a plate. 10 or 15 grammes of concentrated nitric acid are placed in it, and some copper-turnings added. Around this watch-glasses are placed, containing one, or at the most two drops of the oils, and the whole is covered with a flat glass bell. In a few minutes the oil of rosewood acquires a dark yellow colour; the otto has nearly the same colour; whilst the oil of geranium becomes of an apple-green colour, and retains the same for some time.

'This test will serve to distinguish the two oils when in a state of purity, and may even serve to recognise oil of geranium containing the otto, because of the yellow colour which it imparts to the latter; but it is evident that it cannot serve to determine the presence of the oil of geranium in the otto of roses.

'*Sulphuric Acid Test.*—One or two drops of the oil to be tested are put into a watch-glass; the same number of drops of very concentrated sulphuric acid are added, and the two fluids mixed with a glass rod. All the oils are rendered more or less brown by this proceeding; but—

'The otto of roses retains the purity of its odour.

'The oil of geranium acquires a strong and disagreeable odour, which is perfectly characteristic.

'The odour of the oil of rosewood is increased, and becomes somewhat unctuous. It is not, however, characteristic.

'The commercial oil of rosewood acquires an odour distinctly like that of cubebs.

'Of these three methods, that with sulphuric acid is by far the best for distinguishing the otto of roses from the oil of geranium, and for the recognition of the second in the former. The iodine test is also very certain, but it requires considerably more time. The nitrous acid test will serve to recognise the two oils when not mixed, or even to detect the otto of roses in the oil of geranium, but not the latter when mixed with the former.'—'Journ. de Pharm.'

OIL OF VITRIOL. *See* SULPHURIC ACID.

OPIUM.—In the European market three sorts of opium are distinguished, viz. Smyrna opium, opium of Constantinople, opium of Egypt or Alexandria.

Smyrna Opium.—This sort comes into the market in soft lumps, of greater or less bulk; the surface of these lumps is covered with numerous rumex seeds. They are light-coloured inside, but upon exposing the broken or cut surfaces to the air they acquire a dark colour. The smell of Smyrna opium is strong, and indicative of the venomous properties of the substance. The taste is bitter and acrid. This is the best sort of opium; it contains 6·9 per cent. of morphia.

Opium of Constantinople.—This sort is brought into the market in regular flat loaves or cakes, covered with a poppy-leaf. It is drier than the Smyrna opium, and frequently even brittle. It gets soft in the hand, and furnishes a light-coloured paste, which turns brown in the air. It smells like the Smyrna variety, but its odour is somewhat less marked than that of the latter. It contains 5 to 6 per cent. of morphia.

Opium of Egypt or Alexandria.—This is the worst species of opium. It comes into the market in small, very dry, and very flat loaves, exceedingly clean at the surface, and retaining hardly a trace of the leaves in which they were originally enveloped. Its colour is dark-brown; its fracture is clean and shining. It has a very feeble smell, and contains only 3 to 4 per cent. of morphia.

To these three principal species we might add the India opium, which, according to Dr. Thomson, contains three times less morphia than the Smyrna variety.

The following constituents, with the exception of opianine, have been ascertained to exist in most kinds of opium (Miller):

	Meconic acid	from 6 to 8 per cent.
Organic Bases.	1. Morphia	from 6 to 12 ,,
	2. Codeia	less than 1 ,,
	3. Thebaia	,, ,,
	4. Popaverine	,, ,,
	5. Opianine	(from Egyptian opium).
	6. Narcotina	from 6 to 8 per cent.
	7. Narceia.	
	Meconine.	
	Resinous matter.	
	Caoutchouc.	
	Essential oil	4 or 5 per cent.
	Mucilage or gum.	

But opium is most extensively adulterated, *perfectly genuine* samples being, in fact, very rare. The drug of commerce contains *water*, and often *clay, sand, gravel, sulphate of calcium, dung of sheep and oxen, extracts of liquorice, of belladonna, of hemlock, celandin and lettuce, of glaucium luteum, bruised grapes*, freed from their stones, *poppy-stalks* and *husks* (previously beaten up with white of egg); sometimes also the grounds of opium, from which the morphia has been extracted, are sold as the entire drug.

The amount of *water* in opium may be ascertained by drying a weighed portion in the water-oven at 212° and noting the loss. Mineral adulterations may be detected by incinerating a known weight of the drug and weighing and examining the residue. But, as a rule, the best method of testing opium is to determine the quantity of morphia which it contains. For this there are several processes.

1. *Robiquet's Method.*—Make an aqueous extract of the opium in the following manner:—Cut the opium in slices, and let them macerate for 12 hours in six times their weight of water, so that they may become soft; triturate the whole well, and let it stand at rest for 12 hours more; filter through linen, squeeze the residue on the filter, remove it from the filter, and subject it to the same treatment again with a fresh quantity of water. The liquor strained in the first and second operation should then be mixed together,

and evaporated to the consistence of an extract. Redissolve this extract in water, and concentrate the solution. To this concentrated solution add a small quantity of magnesia (10 grains of magnesia per lb. of opium are sufficient), and boil the whole for about one quarter of an hour. This produces a rather considerable deposit of a greyish colour, which consists of free magnesia, of basic meconate of magnesium, of morphine, of narcotine, and of colouring matter. Filter and wash the precipitate with cold water, and macerate it in weak alcohol, *but without boiling*, for morphine is soluble in hot alcohol. This removes a great proportion of the colouring matter, and the narcotic acid, with a very small quantity of morphine. The liquor is filtered again, and the deposit is washed with a little cold alcohol, squeezed, dried, and finally boiled several times with fresh portions of pure or anhydrous alcohol, until this menstruum no longer dissolves anything; the liquors are evaporated, and cooling, the morphine is deposited in almost colourless crystals. By recrystallizing it, it may be obtained quite white. The morphine obtained by this process, however, is very far from being pure; it retains a considerable proportion of narcotine.

2. *Thiboumėry's Process.*—Prepare an extract of opium, as above described, and dissolve it in water; add a large excess of ammonia to the boiling solution, and when cold, filter it; the precipitate collected on the filter should now be thoroughly washed thereon with cold water, and then dried. The dry precipitate must next be boiled with alcohol, sp. gr. 0·84; acetic acid is then added gradually, drop by drop, to the liquor, until it begins to turn red; it is filtered, and the liquor which now holds the morphine and narcotine in solution is precipitated by ammonia; the precipitate is morphine. By this process one pound of pure opium yields 10 drachms of morphine, which does not require purification.

3. *Another Process.*—Take 25 grammes (about 386 grains) of opium, cut it into very thin slices, and macerate it in 150 grammes (about 5¼ fluid ounces) of pure water for 24 hours. Then triturate in a mortar, and pour on a filter the divided parts which the liquid holds in suspension; add more water to the residue, again triturate, and pour it on the same filter. Wash with distilled water until the liquid passes colourless; add to the filtered solution an excess of well hydrated lime, boil for about five minutes; filter and acidify the filtered solution with hydrochloric acid, which saturates the lime and combines with the morphine. The morphine is to be precipitated by ammonia, expelling any excess of the latter by ebullition. The morphine is to be col-

lected on a filter, washed with dilute spirit, and then dissolved in boiling rectified spirit; it crystallizes on cooling. To separate the narcotine, it must be washed with ether. The morphine is then dried and weighed. Good opium should yield 10 per cent. of morphine. (See ACAR on 'Medicinal Substances.')

4. *Guilliermont's Process.*—Take 200 grains of the opium to be tested, cut it in slices, and triturate it in a mortar with four times its weight of alcohol; strain it through linen, squeeze the residue, and pour upon it about 300 grains more of fresh alcohol; mix the strained liquor together in a wide-mouthed bottle, and add thereto 60 grains of ammonia. In the course of 12 hours the morphia will be spontaneously separated, accompanied by more or less narcotine, the morphia covering the interior of the vessel with coloured, large, and gritty crystals, feeling like sand, the narcotine crystallizing in very light, small, white, and pearly needles. Wash these crystals with water, either through a paper-filter or linen, to free them from the meconate of ammonium which they contain; after which the narcotina may be separated from the morphia by decantation in water, which will remove the narcotine, which is lighter. But, according to M. MIALHE, the morphia is more effectually separated by washing the crystals with 60 or 70 grains of ether, morphia being insoluble in that menstruum; this is done by triturating the pulverized crystals with the ether; the morphia is left in an insoluble state; it may then be dried and weighed.

5. *Staples' Process.*—One hundred grains of the powdered and dried opium are exhausted upon a filter with some warm, pure benzol, until the drops of benzol pass through colourless. The opium is subsequently dried upon the filter until the odour of benzol has entirely disappeared, and the powder has acquired a dry appearance: it is then triturated and rinsed into a flask with so much water as to make 10 fluid drachms; the mixture is macerated with occasional agitation for 12 hours, and is then poured upon a moistened filter, and tepid water allowed to percolate through the opium until the washings are quite or nearly colourless. The aqueous solution is then evaporated in a beaker upon the water-bath at a moderate heat to about half a fluid ounce, and this is mixed with an equal bulk of alcohol of a specific gravity of 0·835 through a small filter, and the latter washed with a little dilute alcohol. Then one-half of a mixture consisting of 60 drops of strong ammonia and two fluid drachms of alcohol is added with agitation, and the mixture allowed to stand in a closed flask for six hours, when the remainder of the ammonia is added, and the mixture permitted to rest again for 24 hours. The crystalline

deposit being detached from its sides, the entire contents are gradually poured upon a small tared filter, and the crude crystalline morphia washed with a few drops of cold water and dried at a temperature not exceeding 80° C., when the morphia is exhausted on the same filter with a little warm pure ether, and dried again at the same temperature until upon repeated weighings the weight remains unaltered. The weight indicates the percentage of morphia in the opium.

6. *Schneider's Process.*—Ten grammes (154·340 grains) of the powdered and dried opium are exhausted with a mixture of 150 grammes (4 ounces 6½ drachms) of water and 20 grammes (5 drachms 9 grains) of pure hydrochloric acid; the residue, after extraction, washing, and drying, should not exceed 4·5 grammes (1 drachm 9½ grains) in weight; to the acid fluid 20 grammes (5 drachms 9 grains) of common salt are added; and the liquid, after standing 24 hours, is passed through a filter with the deposit thereon of *narcotia* washed with a little dilute solution of common salt; ammonia is then added to the filtrate in slight excess, and the whole allowed to stand for 24 hours; the crystalline deposit is then collected, redissolved in dilute *acetic* acid and reprecipitated with dilute ammonia; the precipitate is collected upon a moist tared filter, washed with a little cold water, dried at a heat not exceeding 80° C., and weighed; its weight should not be less than one gramme corresponding to 10 per cent. of morphia.

Distinctive Characters of Morphia.—This alkaloid crystallizes in small brilliant prisms, transparent and colourless, or it occurs as a white crystalline powder. Heated in a dry test-tube, the crystals lose their transparency and water, and fuse to a yellow mass, which on cooling again becomes white and crystalline; heated on platinum foil, the morphia burns away, leaving a carbonaceous residue which is wholly dissipated at a red-heat.

Strong sulphuric acid dissolves morphia without coloration; the solution becomes *green* on the addition of a drop of *bichromate of potassium*, and purple with a drop of nitric acid.

Concentrated nitric acid, diluted with an equal volume of water, dissolves morphia with a yellow colour, which, on heating, becomes purple.

Perchloride of iron produces a deep blue colour. Dilute solutions of morphia in acidulated water are not precipitated by excess of potash or soda, by which morphia is distinguished from *narcotia*, nor by bicarbonate of potassium, by which it is distinguished from the *cinchona* alkaloids. They decompose *iodate of potassium*, liberating iodine, which may be extracted by agitating the solution with a little chloroform or bisulphide of carbon, which, on subsiding, acquires a scarlet colour.

The ready solubility of morphia in caustic potash and soda, and its reducing action upon iodic acid and permanganate of potassium, distinguishes it from all other vegetable alkaloids. The presence of *narcotia* is indicated by a white crystalline residue left on evaporating on a watch-glass a little pure ether, agitated with a few grains of the morphia.

OXALIC ACID.—Oxalic acid occurs in transparent oblique rhombic prisms, containing 28 per cent. of water of crystallization, which they lose in dry and warm air, the crystals crumbling down to a soft white powder of anhydrous acid, which may be sublimed in a great measure without decomposition. Heated upon platinum-foil, the crystals first fuse with slight crepitation, and finally are competely dissipated, emitting inflammable fumes.

Oxalic acid is soluble in eight parts of cold and in its own weight of boiling water. The solution is intensely sour. It should not produce a turbidity when mixed with alcohol, but when dropped into lime-water, or into a solution of sulphate of calcium, a copious white precipitate, insoluble in acetic acid but readily soluble in hydrochloric acid, should be produced. When heated with concentrated sulphuric acid, oxalic acid is resolved into carbonic acid and carbonic oxide (equal volumes), without being charred, the latter burning with a blue flame.

Crude commercial oxalic acid generally leaves a very small trace of residue, too insignificant to impair the quality of the acid or render it unfit for its common technical applications.

OXIDE OF COBALT. *See* COBALT.

OXIDE OF ZINC. *See* ZINC.

OXYMURIATE OF MERCURY. *See* CORROSIVE SUBLIMATE.

PACKONG. *See* GERMAN SILVER.

PALM OIL. *See* OIL.

PAMPHOLIX. *See* OXIDE OF ZINC.

PAPERS (Coloured). *See* BLANC MANGE.

PEPPER.—Pepper is the fruit of various kinds of plants, which grow principally in India, Java, and the Eastern islands. The following varieties are met with in commerce—namely, black pepper, white pepper, cayenne pepper, long pepper, and cubebs.

Black Pepper.—Good black pepper should have a very hot, pungent taste, and a strong aromatic odour; the grains should be hard and not very full of wrinkles; that which is in small shrivelled grains is of inferior quality; neither should the grains break easily when pressed between the fingers. Black pepper from Malabar is the best.

White pepper is the same substance as black pepper, from which the outer coating has been removed by blanching; it is accordingly much less pungent and strong than black pepper.

Both *black* and *white pepper*, when ground, are very often adulterated, and sometimes in an extraordinary degree, with ground *oil-cake, linseed-meal,* and other like substances. The best way of guarding against adulteration is, like for coffee, to buy the article in the grain, and to examine whether it has the appearance which we have described above, and which are the criteria of a good quality.

MM. Bussy and Boutron-Charlard ('Traité des moyens de reconnoitre les Falsifications des Drogues simples et Composées') describe a falsification of the grains of pepper, by *manufacturing* them with cayenne pepper, mustard, and various acrid and pungent powders, made into a paste with mucilage, and granulated in such a way as to bear considerable resemblance with genuine pepper, and scarcely recognizable when mixed with a suitable quantity of the latter. They state that the manufacturer, in order to imitate the genuine article more closely still, introduces into the interior of the false grains a mustard-seed as a kernel to the above paste, so that on breaking the artificial grain the mustard-seed, which has become loose by drying, falls out, and simulates exactly the little hollow which is generally seen in the centre of the genuine grains. The best way of detecting this fraud consists in throwing a certain quantity of the suspected pepper into tepid water; the genuine pepper remains solid and retains its spherical shape, whilst the spurious grains swell out, soon become soft and gluey, and on stirring become disintegrated and fall into powder.

For the purpose of ascertaining whether ground pepper is genuine and of good quality, the best way consists in ascertaining the amount of piperine contained in the pepper under examination. This may be done by treating 1,000 grains, for example, of pulverized pepper with alcohol of sp. gr. 0·833 until they are exhausted. The solution is then distilled to the consistence of an extract; the extract so obtained is then mixed with a solution of caustic potash, which dissolves the resin, and leaves a green powder, which should be first well washed with water, and then dissolved in alcohol of sp. gr. 0·833. By spontaneous evaporation the solution yields quadrilateral transparent obliquely-truncated crystals of piperine, which are tasteless and inodorous, insoluble in cold water, sparingly soluble in boiling water, from which they separate on cooling; soluble in alcohol, especially with the help of heat. The alcoholic solution is precipitated by water. Good pepper yields about 1½ per cent. of piperine; and of course, if the article is adulterated, the reduced proportion of the piperine obtained may serve to indicate the quality of the pepper, or the extent of the fraud.

PERUVIAN BARK.—*Estimation of the Alkaloids in Cinchona Barks* (Hoffmann, 'Manual of Chem. Anal. as applied to the Examination of Medicinal Chemicals').—A fair average quantity of the bark is reduced to powder. 10 drachms are mixed with an equal bulk of coarsely-powdered glasss, and introduced into a comparatively narrow glass percolator, whose lower end is drawn into a point and loosely closed with cotton; the powder is covered with a layer of glass or quartz, and when the percolator is placed in a perpendicular position, water, acidulated with about one per cent. of concentrated sulphuric acid, is introduced, until it has penetrated the column and commences to drop out; then the upper orifice is corked, and the whole allowed to stand for several hours, when the cork is removed, and the percolation with the acidulated water is continued until a few drops of the menstruum, received in a test-tube, cease to have a bitter taste or to become turbid on the addition of ammonia. The entire liquid is then poured into a porcelain dish, and three drachms of powdered calcined marble are added, and the mixture evaporated to dryness on a water-bath. The dry residue is triturated, introduced into a flask, and repeatedly and completely extracted with strong alcohol. The filtered alcoholic solution is evaporated in a small tared beaker-glass at a gentle heat, and when dry the beaker is allowed to stand for several hours at a temperature near 80° C.; it is finally weighed; and when the tare is subtracted, the difference answers approximately to the quantity of cinchona alkaloids contained in 10 drachms of the bark.

According to F. Hoffmann, the most reliable method for the estimation of the value of commercial cinchona bark designed for the manufacture of sulphate of quinine, is the preparation of the sulphate of quinine on a small scale by the process of the U.S. Pharmacopœia.

12 ounces of the bark, in coarse powder, are thoroughly mixed with 4 pints of water and half an ounce of hydrochloric acid of 1·160 sp. gr. The mixture is allowed to macerate for twelve hours, and is then gently boiled in a porcelain capsule for about one hour; it is then strained through muslin, and the residue is boiled twice successively with half of a mixture consisting of three pints of water and three drachms of hydrochloric acid, and strained; the powder is finally submitted in the muslin to a gentle pressure, and this is repeated again after it has been moistened

with about six ounces of boiling water. The obtained liquids are mixed in a porcelain capsule, and heated; now, while hot, a mixture of ten drachms of lime, previously slaked with eight ounces of water, is gradually added, with constant stirring with a glass rod until the solution of lime, and the corresponding formation of a precipitate of quinine, cease, or until the paper turns turmeric-paper brown. The precipitate is collected upon a filter, and washed with distilled water until this ceases to cause a turbidity, when a few drops are allowed to fall into a solution of nitrate of silver acidulated with nitric acid; the precipitate is then dried, and when detached from the filter reduced to a fine powder, which is successively exhausted with decreasing quantities of boiling alcohol, separating the alcohol from the precipitate by decantation, which operation is repeated until the alcohol is no longer rendered bitter. The obtained alcoholic solutions are mixed, and are concentrated to a syrupy consistence either by evaporation or distillation; the remainder is then transferred and rinsed into a flask with twelve ounces of boiling water; it is then heated to boiling, and so much dilute sulphuric acid is added as just completely to dissolve the quinia; then half an ounce of common animal charcoal is added, or so much as to leave the liquid of a faintly acid reaction upon blue litmus-paper. After a few minutes' gentle stirring, the mixture is filtered while hot, and the residue washed on the filter with a little boiling water; the entire filtrate is then set aside to crystallize. The crystals are separated from the liquid, which is allowed to drop off as much as possible, and they are then dried in a porcelain capsule, covered with bibulous paper, at a heat not exceeding 50° C., taking care to avoid efflorescence of the dry crystals. The remaining liquid is evaporated at a boiling heat to nearly two-thirds of its volume, and is then allowed to crystallize again; these crystals are separated and dried as before. The mother-water may be made to yield an additional quantity of quinia sulphate by precipitating the quinia with ammonia, and treating the precipitated alkaloid, as before, with proportionate quantities of distilled water, sulphuric acid, and mineral charcoal.

The entire yield of quinia sulphate, when dry, represents the available quantity of the salt obtained from 12 ounces of the bark, which number has to be multiplied by 8·33, in order to express the percentage value of the bark in quinia sulphate.

The 'British Pharmacopœia' gives the following process for the estimation of the quinia in cinchona barks:—

'Boil 100 grains of the bark, reduced to a fine powder, for a quarter of an hour in a fluid ounce of distilled water, and allow it to macerate for 24 hours. Transfer the whole to a small percolator, and, after the fluid has ceased to drop, add at intervals about an ounce and a half of similarly acidulated water, or until the fluid which passes through is free from colour. Add to the percolated fluid solution of subacetate of lead until nearly the whole of the colouring matter has been removed, taking care that the fluid remains acid in reaction. Filter, and wash with a little distilled water. To the filtrate add about 35 grains of hydrate of potash, or as much as will cause the precipitate which is at first formed to be nearly redissolved, and afterwards 6 fluid drachms of ether. Then shake briskly, and having removed the ether, repeat the process twice with 3 fluid drachms of ether, or until a drop of the ether employed leaves on evaporation scarcely any perceptible residue. Lastly, evaporate the mixed etherial solutions in a capsule. The residue, which consists of nearly pure quinia, when dry, should weigh not less than 2 grains (2 per cent.), and should be readily soluble in dilute sulphuric acid.

PHOSPHATE OF SODIUM.—Phosphate of sodium is met with in oblong rhombic crystals, or in small white, nacreous, shining plates, which do not readily effloresce by exposure; of a slightly saline but not bitter taste. Phosphate of sodium turns syrup of violets green. It is soluble in three parts of cold and two of boiling water. Its solution is precipitated by barytic salts, and the precipitate is completely soluble, without effervescence, in nitric acid.

The salts by which phosphate of sodium is generally contaminated are *sulphate* or *carbonate of sodium*, *chloride of sodium*, and sometimes a little *arsenic* or *arsenious acid*.

The presence of *sulphate of sodium* is detected by dissolving a portion of the salt in distilled water, and acidifying it with nitric or hydrochloric acid. If a solution of chloride of barium, or of nitrate of barium, being now added, produces a white precipitate, *insoluble in water and in acids*, it is sulphate of barium; the liquor containing the precipitate should be boiled a little in order to agglomerate it, and after settling, it is collected on a filter, washed, dried, and ignited. 117 grains of sulphate of barium represent 40 of anhydrous sulphuric acid, and consequently 172 of dry sulphate of sodium; or each grain of sulphate of barium represents 0·34368 grain of sulphuric acid.

The presence of *carbonate of sodium*, or of any other carbonate, is detected by moistening the salt with a little water, and pouring an acid upon it, which will produce a disengagement of carbonic acid, the quantity of which may be readily estimated by Drs. FRESENIUS' and WILLS' apparatus. (See *Alkalimetry.*)

The quantity of carbonate of sodium in phosphate of sodium may also be estimated by carefully precipitating the solution with nitrate of barium, collecting the precipitate, washing, drying, and then weighing it. It should then be treated by weak nitric acid, which will redissolve the carbonate and phosphate of barium, and leave any sulphate which may be present in an insoluble state; the filtrate being now saturated by ammonia, the phosphate of barium alone will be precipitated, and after separating it by filtering, the baryta left in the solution may now be precipitated by boiling with carbonate of ammonium; each grain of carbonate of barium thus precipitated corresponds to 0·545 grain of carbonate of sodium. If a solution of carbonate of sodium being added to one of phosphate of sodium renders it turbid, it is a proof of the presence of an earthy base.

The presence of *chloride of sodium* is recognized by dissolving a portion of the phosphate of sodium under examination in water, acidifying the solution with nitric acid, and testing with solution of nitrate of silver, which will then produce a precipitate of chloride of silver, insoluble in dilute acids, but immediately soluble in ammonia.

Arsenic and *arsenious acids*, which exist sometimes in phosphate of sodium, may be detected by dissolving the phosphate, adding hydrochloric acid to the solution, and passing a current of sulphuretted hydrogen through; a yellow precipitate of sulphide of arsenic is produced, especially by applying heat. If the solution thus saturated with the gas be left at rest for about twelve hours in a warm place, the whole of the arsenic will be precipitated.

PINCHBECK. *See* BRASS.

PLATINUM.—*Analysis of Platinum Ores* (MM. DEVILLE and H. DEBRAY, 'Annales de Chimie et de Physique').—The following substances are contained in the ores of this valuable metal:—1, *Sand*; 2, *Osmide of Iridium*; 3, *Platinum*, *Iridium*, *Rhodium* and *Palladium* (probably an alloy); 4, *Copper* and *Iron*; 5, *Gold*, and a *little Silver*.

(1.) *Determination of the Sand.*—This is effected by heating a known weight (about 2 grammes) of the ore with five or six times its weight of pure granulated silver in a crucible, the sides of which have been previously glazed by melting borax in it; over the metals 10 grammes of fused borax and one or two pieces of wood-charcoal are placed, the heat is raised a little above the melting-point of silver, at which it is kept for some time; the vitreous matters are dissolved by the borax, and all the metals are contained in the button of silver which is found at the bottom of the crucible when cold; it is heated to faint redness, and weighed; the weight, subtracted from the sum of the weights of the ore and silver employed, gives the amount of sand.

(2.) *Determination of Osmium and Iridium.*—About 2 grammes of the ore are repeatedly treated with aqua-regia until the whole of the platinum is dissolved, which is known by the solution being no longer coloured. The insoluble residue is *osmide of iridium* in the form of spangles, together with the sand; it is washed by decantation, dried, and weighed; by subtracting the weight of the sand obtained in the former operation, we get the weight of the osmide of iridium.

(3.) *Determination of the Platinum and Iridium.*—The solution obtained in the last operation is evaporated to dryness on the water-bath, redissolved in a little water, alcohol added, and then crystals of sal-ammoniac in great excess; after standing for twenty-four hours the orange-yellow or reddish-brown precipitate is thrown on a filter, and washed with alcohol: it consists of the ammonio-chlorides of platinum and iridium, but a portion still remains in the solution; the double chlorides of the two metals, after being dried, are heated to low redness in a platinum crucible, and the filter is burnt at the lowest possible temperature; to favour the reduction of the iridium, and the escape of the last traces of osmium, a piece of paper saturated with turpentine is introduced into the crucible. The heat is now raised gradually to whiteness, and the reduction of the metal is finished in a current of hydrogen. The filtrate from the double chlorides of platinum and iridium is concentrated until the greater part of the sal-ammoniac crystallizes out; it is then allowed to cool, upon which a deep violet-coloured precipitate is formed; this is ammonio-chloride of iridium, mixed with a little of the corresponding platinum salt; it is collected on a filter, and washed first with a solution of sal-ammoniac, and then with alcohol, after which it is dried and ignited in a current of hydrogen. The results of the two reductions are weighed and digested at about 120° F., with repeated portions of aqua-regia diluted with five or six times its bulk of water, till the liquid is no longer coloured; all the *platinum* is dissolved, leaving as a residue *iridium* in a state of purity.

(4.) *Determination of the Palladium, Iron, and Copper.*—These metals are contained in the liquor from which the platinum and iridium have been separated. The alcohol and chloride of ammonium are evaporated off, the removal of the latter being facilitated by the addition of nitric acid, which transforms it into nitrogen and hydrochloric acid; the evaporation is continued almost to dryness; the residue is transferred to a weighed porcelain crucible, and when dry is moistened with sulphide of ammonium, and loosely covered with two or three grammes of pure sulphur. The crucible is covered, placed in a larger clay crucible, and surrounded with pieces of wood-charcoal; a cover is then put upon the clay crucible, and it is brought slowly up to a bright red-heat, the fire being lighted at the top of the furnace in order to avoid the projection of any matter from the crucible, which might happen if it were too quickly heated. When cold, the inner crucible contains *palladium* in the metallic state, with the sulphides of *iron* and *copper*, and also the *gold* and the *rhodium*. The mixture is digested for a long time at 150° with concentrated nitric acid, which dissolves the *palladium*, *iron*, and *copper*, converting them into nitrates. These are dissolved out by water, and the residue well washed; the solution and washings are evaporated to dryness, and then calcined at a strong red-heat; the *palladium* is reduced, and the *iron* and *copper* are converted into oxides, which are easily separated from the palladium by strong hydrochloric acid, and the latter, now in a state of purity, is strongly ignited and weighed. The chlorides of copper and iron are treated in the usual way for the determination of each metal.

(5.) *Determination of the Gold.*—This metal is contained in the residue (4), insoluble in nitric acid: it is weighed, and then treated with dilute aqua-regia, which dissolves the *gold*, and sometimes, but rarely, a trace of *platinum*, the presence of which is detected by chloride of ammonium. The difference between the weight of the crucible before and after the treatment by aqua-regia gives the weight of the gold.

(6.) The residue left in the crucible is *rhodium*, which is reduced in a current of hydrogen, and then weighed.

MM. Deville and Derbray caution experimenters to beware of the ill effects of osmium, which particularly attacks the eyes; and also to avoid breathing the vapour from the aqua-regia.

Berzelius gives the following analysis of the ores of this mineral. (See p. 317.)

PORTER. *See* Beer.

POTASH.—The substance known under that name in commerce is the impure carbonate of potassium, obtained by lexiviating the ashes of burnt plants and evaporating the ley to dryness; the result is an impure carbonate of potassium, contaminated by variable proportions of sulphate of potassium, of chloride of potassium, of silica, alumina, oxide of iron, of manganese, &c.

Commercial potash is in lumps of a brown colour, brick-red

Constituents	Nichne-Taglisk, in Siberia		Goro Blagodat in Siberia	South America		
	Non-Magnetic	Magnetic		90		
Platinum . . .	78·94	73·58	86·50	84·30	86·16	84·34
Iridium . . .	4·97	2·35	,,	1·46	1·09	2·58
Rhodium . . .	0·86	1·15	1·15	3·46	2·16	3·13
Osmium . . .	,,	,,	,,	1·03	0·97	0·19
Palladium . . .	0·28	0·30	1·10	1·06	0·35	1·66
Iron	11·04	12·98	8·32	5·31	8·03	7·52
Copper	0·70	5·20	,,	0·74	0·40	,,
Alloy of osmium and iridium, and foreign matter . .	1·96	2·30	1·40	0·72	2·01	1·87

internally, very hard, deliquescent, and of an intensely alkaline, bitter, caustic taste. The brown colour is due to the presence of organic matter. When the potash produced, as above described, is put into a reverberatory furnace and calcined, the vegetable matter is destroyed, and the potash becomes of a bluish-white colour, and is called pearlash.

Potash and pearlash are chiefly manufactured in Russia, Poland, and America, the immense forests of those countries supplying an abundance of fuel, and consequently of ashes. Both potash and pearlash are of great importance in several manufactures. The processes by which their commercial or alkaline value can be determined have been fully detailed in the article on *Alkalimetry.*

Caustic Potash, Hydrate of Potash.—Pure or caustic potash is obtained from the commercial potash (carbonate of potassium) by dissolving one part of the latter substance in about 10 or 12 parts of water, boiling the solution in a clean iron vessel, and adding slaked lime, in small portions at a time, to the boiling solution, until on filtering a portion of it and receiving the drops in hydrochloric acid, not the slightest effervescence is observed; ordinarily about one part of quick lime, previously slaked, is sufficient for two parts of commercial potash. The solution is then allowed to subside, the clear liquor is decanted or syphoned out, and evaporated in a polished iron vessel, or better still, in a basin of pure silver, until it assumes the appearance of a syrupy mass, which concretes in cooling.

Caustic potash is ordinarily in flat, irregular, brittle fragments, of a grayish-white and sometimes reddish colour; when pure, they should be perfectly white; their taste is excessively caustic, and they have a slight odour of potash ley. As they are extremely deliquescent, and attract promptly the carbonic acid of the air by exposure, they should be kept in well stoppered flasks.

Pure or caustic potash is generally contaminated by *silica* and *alumina*, which impurities may be readily detected by dissolving a portion of the potash under examination in water, supersaturating the alkali with hydrochloric acid, evaporating to dryness, moistening the dry residuum with dilute hydrochloric acid, and then, after a little while, pouring a sufficient quantity of water upon it; the silica, if any be present, will be found in an insoluble state. It may then be collected on a filter, washed, dried, ignited, and weighed.

The liquor filtered from the silica being tested with carbonate of ammonium, will produce a white, flaky precipitate of *alumina*, if that earth be present. This precipitate, which is bulky, should be washed with hot water, thoroughly dried, ignited, and then weighed.

If the potash contains any *peroxide of iron*, it has a brown or reddish colour, and upon dissolving it in boiling water the peroxide of iron is left in an insoluble state; the quantity may be determined by collecting it on a filter, washing it thoroughly with hot water, drying it perfectly, and then igniting and weighing it.

If a chloride (chloride of potassium) be present, it may be detected by dissolving a given weight of the potash in water, supersaturating the solution with nitric acid, and then adding a solution of nitrate of silver, which will produce a precipitate of chloride of silver. The liquor containing it should be warmed, after which the chloride of silver may be collected on a filter, washed, dried, fused on a porcelain crucible or capsule, and weighed. 143·5 grains of chloride of silver represent 74·5 grains of chloride of potassium, or one equivalent of any other chloride.

Or the solution, supersaturated with nitric acid, may be tested with a solution of nitrate of silver of a known strength, as for the assay of silver (see *Silver*). Chloride of potassium is almost invariably present in the potash of shops.

If the solution filtered from the chloride of silver above mentioned, being tested with solution of chloride of barium, yields a white precipitate, insoluble in water and in acids, it is a proof of the presence of a *sulphate*; the precipitated sulphate of barium may then be collected on a filter, washed, dried, ignited, and weighed. 116·5 grains of sulphate of barium represent 40 grains of sulphuric acid, and consequently one equivalent of sulphate.

If a *carbonate* be present (carbonate of potassium), the addition of an acid will produce an effervescence. The quantity of the carbonate may be determined either by means of Drs. FRESENIUS' and WILLS' apparatus (see *Alkalimetry*), or else a given weight of the solution being diluted with water, a solution of chloride of barium should be added, which will then produce a precipitate of carbonate of barium. When the precipitate has completely settled, which requires several hours, the liquid is poured on the filter, hot water is then added to the precipitate, and after having shaken it violently, it is allowed to settle again. This operation having been repeated several times, the precipitate is finally collected on a filter. The funnel must be sheltered from the contact of the air during the filtering, in order to guard against the carbonic acid of the air augmenting the quantity of the earthy carbonate produced. The precipitate should then be washed until the filtered liquor ceases to afford a precipitate when tested with nitrate of silver, to which a little free nitric acid has been added. The carbonate of barium on the filter is then dried, ignited, and weighed; it does not lose any carbonic acid by ignition. Each grain of carbonate of barium contains 0·22414 grain of carbonic acid, which represents therefore 0·63166 grain of carbonate of potassium.

If both a *sulphate* and a *carbonate* are present, and a solution of chloride of barium is used, the precipitate will consist of both sulphate and carbonate of barium. The collective precipitate should therefore be washed, dried, and weighed, after which it should be treated by hydrochloric acid, which will dissolve the carbonate only, and leave the sulphate in an insoluble state, the weight of which being now taken will show the relative proportion of both substances, the loss from the collective weight indicating the proportion of carbonate.

If traces of lime are present in the potash, oxalic acid will produce a precipitate of oxalate of calcium.

Sulphate of Potassium (*Sal du Duobus*).—This salt crystallizes in short six-sided prisms, terminated by hexaedral pyramids; the crystals are anhydrous, hard, white, unalterable by exposure; their taste is slightly bitter; they decrepitate strongly when heated. When strongly ignited they fuse, but are not decomposed. Their sp. gr. is 2·4073.

According to M. GAY-LUSSAC:

100 parts of water at 61° F. dissolve 10·5 parts of sulphate of potassium.

100 parts of water at 120·2 F. dissolve 16·9 ditto.

100 parts of water at 215 F. dissolve 26·3 ditto.

Sulphate of potassium is completely insoluble in alcohol.

The sulphate of potassium of commerce is often contaminated by *sulphate of zinc, of iron, of copper, of magnesia, of lime*, and sometimes by *bisulphate of potassium.*

The presence of *sulphate of zinc* is detected by dissolving a portion of the salt in water, acidifying with a little nitric acid, and supersaturating with ammonia. If *iron* is present, reddish-brown flakes of peroxyde of iron will be precipitated, and should be separated by filtering. If *copper* is present, the solution will have a blue tinge. Admitting, however, that the salt under examination contains no other impurities than sulphate of zinc, the solution will remain perfectly clear after the addition of the ammonia; that is to say, at first the ammonia may determine a white precipitate, which, however, will be immediately redissolved by an excess of the reagent; if it is not redissolved it is a proof that some other base is present, and the liquor must be filtered. However this may be, if hydrosulphuret of ammonia, being added to the clear, colourless, strongly ammoniacal liquor, produces a white precipitate or cloudiness, insoluble in an excess of hydrosulphuret of ammonia, it is certainly sulphide of zinc. If the sulphide of zinc so produced is in sufficient quantity, it may be collected on a filter, redissolved in hydrochloric acid, boiled until all odour of sulphuretted hydrogen has disappeared, filtered, and reprecipitated as carbonate of zinc by carbonate of potassium or of sodium, with the precautions which are indicated farther on in the article on *Zinc* and *Zinc Ores.*

If the solution contains the slightest trace of iron, the precipitated sulphide of zinc produced by hydrosulphuret of ammonia, instead of being white, may be gray, or blackish, or interspersed with black flakes, or altogether black, according to the quantity of iron present.

If *iron* is present, it will have been precipitated from the solution by ammonia, in the state of peroxide of iron, which may be collected on a filter, washed, dried, ignited, and weighed. If both iron and zinc are present, they may be separated by means of a solution of neutral succinate of ammonia, or by carbonate of baryta, exactly as is described in the article on *Zinc* and *Zinc Ores.*

If *copper* is present, the addition of ammonia will have produced a blue tinge or colour as above said; or if in too small quantity to be thus detected, the operator may test the aqueous solution of the salt, to which no ammonia has been added, with ferrocyanuret of potassium, which will then produce a reddish-brown precipitate of a crimson tinge. If the precipitate or colour is blue, it is due to the presence of iron.

Generally, only a trace of these impurities is indicated by the above tests.

If magnesia alone is present, a portion of the solution of the salt, to which no ammonia has been added, being tested with caustic potash, will produce a white precipitate of hydrate of magnesia. Or else the solution of the salt may be mixed with an excess of solution of sal-ammoniac, and then tested with a solution of phosphate of sodium and ammonia, which will immediately produce a white precipitate of ammonia-phosphate of magnesium.

If *lime* is present, the solution of the salt being tested with a solution of binoxalate of potassium, or of oxalate of ammonium, will produce a white precipitate, or be rendered turbid.

The presence of *bisulphate of potassium* is detected, because the salt, instead of being neutral to test-paper, reddens blue litmus-paper. The salt should be drenched with water before testing with litmus-paper.

Supposing, however, which is not probable, that all these impurities are present at the same time, they may be detected as follows:—

1°. Dissolve the salt in water, acidify the solution with hydrochloric acid, and pass a stream of sulphuretted hydrogen through it until it smells strongly of the gas; if a black or dark brown precipitate is produced, it is sulphide of copper. Confirm, by collecting the black precipitate on a filter, redissolve it in nitric acid, and supersaturate the nitric acid solution with ammonia; if a blue colour is produced, *copper* is present.

2°. To the liquor filtered from the sulphide of copper, add an excess of sal-ammoniac, and then ammonia, and whether a precipitate is produced or not, add an excess of hydrosulphuret of ammonia.

If a white precipitate only has been produced, it is sulphide of zinc; if the precipitate is gray or black, zinc and iron may be present. Collect the precipitate on a filter, and keep the filtrate for further examination; wash the precipitate and redissolve it in nitric acid, and supersaturate the solution with ammonia. If a reddish-brown precipitate is produced, insoluble in an excess of ammonia, it is peroxide of iron. Confirm, by redissolving it in a small quantity of hydrochloric acid, so that the solution may be as neutral as possible, and test a portion of this with solution of ferrocyanide of potassium; a blue precipitate is formed; test another portion with tincture of galls, a black colour is produced. *Iron* is present.

If the liquor filtered from the precipitate of peroxide of iron produced by ammonia, and which is strongly ammoniacal, clear and colourless, being now tested by hydrosulphuret of ammonia, yields a white precipitate, it is sulphide of zinc. The white precipitate which hydrosulphuret of ammonia produces in a clear, colourless, strongly ammoniacal or alkaline solution, can hardly be anything else than sulphide of zinc.

3°. The solution which was filtered from the precipitate produced by ammonia and hydrosulphuret of ammonia, and which was kept for further examination, should now be boiled with hydrochloric acid until all odour of sulphuretted hydrogen has disappeared; filter, if necessary, and boil the filtrate with an excess of carbonate of ammonium mixed with ammonia. If a precipitate is produced, it is carbonate of calcium. Collect the precipitate upon a filter, redissolve it in a small quantity of hydrochloric acid, neutralize with ammonia, and test with oxalate of ammonium; if a white precipitate is produced, *lime* is present.

If to the liquor filtered from the precipitate produced by boiling with carbonate of ammonium mixed with ammonia, the further addition of phosphate of sodium produces a white precipitate, it is *magnesia.*

POTTERS' ORE. *See* GALENA AND ALQUIFOUX.

POUNXA. *See* BORAX.

PRINCE RUPERT'S METAL. *See* BRASS.

PRUSSIAN BLUE.—The Prussian blue of commerce is seldom pure: it generally contains *hydrate of alumina,* or *basic salts of aluminum* and *iron*; it is also frequently adulterated with *starch,* and with *carbonate of calcium.*

With respect to *alumina,* its presence could hardly be called an adulteration, because formerly a certain quantity was always added in order to saturate the free alkali employed in the manufacture, and the precipitated alumina does not interfere with the colour, at least to the same extent as peroxide of iron, which would be precipitated by the alkali and give a green hue to the product. Prussian blue, however, being always prepared now with ferrocyanide of potassium, the addition of alum is perfectly unnecessary, except as a means of augmenting the weight of the pigment.

Prussian blue can be purified by first pulverizing it, and digesting it in dilute hydrochloric acid for about forty-eight hours, and pouring a large quantity of water upon the mass. The Prussian blue remains insoluble, whilst all the other salts with which it was mixed are taken up by the acid and remain in solution in the supernatant liquor, which should be decanted, and replaced by a fresh quantity of water, and so on, until a few drops of water on being evaporated leave no residuum. Distilled water must be used, because if common water containing bicarbonate of calcium in solution were employed, a portion of the Prussian blue would be decomposed into oxide of iron and ferrocyanide of calcium, which, being soluble, would be washed away.

Prussian blue may also be purified by dissolving a given weight of it in concentrated sulphuric acid, or in hydrochloric acid, and pouring the solution, drop by drop, in a large quantity of water; the pure Prussian blue precipitates, whilst the other salts remain in solution in the water. The Prussian blue is then collected upon a filter, washed and dried in an oven at between 212° and 230° Fahr., until it no longer diminishes in weight.

Prussian blue is known to contain *stareh* by boiling a portion of it in water, which will thicken into a paste.

The colouring power of Prussian blue may also be tested by grinding a given weight of it with twenty-five or thirty times its weight, or a larger proportion still, of white lead and oil, and comparing the colour which is thus yielded with that produced by a same weight of genuine Prussian blue treated in the same manner.

The characteristics of good Prussian blue are lightness, a deep, fine, blue colour, with a coppery hue; it should adhere very strongly to the tongue, and should not effervesce when treated by acids, nor thicken when boiled in water.

PRUSSIATE OF POTASH. *See* FERROCYANIDE OF POTASSIUM.

PYROLIGNEOUS ACID. *See* VINEGAR.

QUICKSILVER. *See* MERCURY.

QUININE (Sulphate of Quinine).—Sulphate of quinine is prepared principally from the yellow or Calysaya bark (see *Peruvian Bark*), by the action of sulphuric acid upon quinine.

Sulphate of quinine is in small, silky, flexible tufts, or needles, somewhat resembling asbestos, and has an excessively bitter taste, sparingly soluble in cold water (1 part in 740 of cold water), soluble in 30 parts of boiling water, very soluble in alcohol, especially in hot alcohol, and in ether. This salt effloresces by exposure; when heated it fuses like wax, and at a temperature of 212° Fahr. it becomes phosphorescent, especially by friction.

The solution of sulphate of quinine (when not too dilute) is precipitated by potash, soda, and ammonia, in the state of a flocculent white precipitate, which is hydrate of quinine, which is only very sparingly soluble in an excess of the precipitant. An excess of ammonia, however, redissolves partially the precipitate.

Tartaric, oxalic, and gallic acids, and the soluble salts of these acids, and also the infusion of galls, produce in the solution of sulphate of quinine a precipitate which is soluble in an excess of acid.

Bicarbonate of sodium (according to Dr. FRESENIUS) immediately precipitates a concentrated solution of sulphate of quinine, and in dilute solutions a precipitate is produced by that reagent in the course of a quarter of an hour, especially by stirring the liquor briskly.

This very important article is sometimes adulterated by admixtures of *gum, sugar, starch, chalk, sulphate of barium, boracic acid stearine, sulphate of cinchonine, salicine,* &c.

These frauds may be recognized in the following manner:—

If the sulphate of quinine under examination contain any earths, such as chalk, sulphate of calcium, &c., their presence may be detected by incinerating a portion of the sample, which will leave the earths in the state of fixed ashes, the weight of which may then be directly ascertained. Pure sulphate of quinine should not leave a trace of residue; or, as sulphate of quinine is soluble in alcohol, a portion of the suspected sulphate of quinine may be treated by this menstruum, which will take up the sulphate of quinine (and of cinchonine, also the salicine if present), but will leave all the earthy impurities, stearine, gum, and starch in an insoluble state; these impurities may then be separated by filtering, and weighed.

If any *stearine*, or *stearic acid*, has been mixed with sulphate of quinine, treat a portion of the sample with water acidified with sulphuric acid; the sulphate of quinine will dissolve, and the stearine will be left in an insoluble state *floating* on the surface of the liquid; if heat be now applied, the stearine will agglomerate into small transparent drops, which, on cooling, become solid and opaque.

The presence of *sugar* may be detected by the odour of burnt sugar, which is evolved on burning a portion of the suspected article upon a strip of platinum foil. A more certain method, however, consists in dissolving a given weight of the sulphate of quinine in water, and adding baryta thereto, which will precipitate both the sulphuric acid and the quinine. The liquor should then be filtered, or a current of carbonic acid should be passed through the filtrate, in order to precipitate the excess of baryta in the liquor. The precipitate formed being separated by filtering, the sugar alone remains in solution in the liquor, and may then be easily detected by its sweetness, especially after concentrating the filtrate.

The presence of *sugar* and of *gum* may also be detected by dissolving a given weight of the sample in water, and adding carbonate of potassium, which precipitates the quinine (and cinchonine); the precipitate may be collected on a filter, dried, and weighed. The sugar and gum remain in solution with the sulphate of potassium produced from the decomposition of the carbonate of potassium employed, and with any salicine that may be present. By evaporating the solution, the presence of sugar will be recognized by the sweet taste of the solution; if bitter, salicine is present, and may be detected, as will be shown presently. The solution should now be evaporated to dryness at a gentle heat, and the residuum being treated with spirits of wine, the sugar will be dissolved, but the *gum* and *sulphate of potassium* will remain in an insoluble state. Filter in order to separate the sugar, and pour hot water on the insoluble residuum, which will then be redissolved; test that aqueous solution with persulphate of iron; gum, if present, will at once be precipitated in the form of a yellow gelatinous precipitate.

Starch may be detected by boiling a portion of the sample with water, and allowing the whole to become quite cold. Test the *cold* decoction with aqueous solution of iodine; if a blue or nearly black colour is produced, starch is present.

All *organic substances—starch, gum, sugar, stearine*, &c.—mixed with sulphate of quinine, may be readily detected by pouring a few drops of concentrated sulphuric acid upon two or three grains of the suspected sulphate, previously placed in a small porcelain capsule. The pure sulphate of quinine is immediately dissolved, but the *starch, gum*, or *sugar* will be charred, and the stearine left in an insoluble state; but even the stearine becomes charred by applying heat, whilst sulphate of quinine is not altered by the treatment which converts it into bisulphate of quinine.

If *salicine* be present, the addition of concentrated sulphuric acid will produce a deep blood-red colour. This property of being coloured red by sulphuric acid belongs also to other bitter principles; and, moreover, we should remark that this reaction takes place only when the proportion of salicine mixed with the sulphate of quinine is somewhat considerable; for when under 10 per cent. a brown colour only is produced by treatment with concentrated sulphuric acid, just as if an ordinary organic matter was present. M. Pelletier directs, to dissolve the suspected sample in six times its weight of concentrated sulphuric acid, and then to dilute the whole with 12 parts of water, which will precipitate the salicine in a colourless state, after which it may then be identified by the red colour which is produced by treatment with concentrated sulphuric acid, as above mentioned; or, a portion of the sample may be dissolved in water, and filtered if needful; hydrochloric acid is then added, and the mixture is boiled for some time. If a precipitate be produced, it is salicine; collect it on a filter, and confirm, by treatment with concentrated sulphuric acid.

The presence of *sal ammoniac*, or other *ammoniacal salts*, is detected in sulphate of quinine by the odour of ammonia, which is evolved when a portion of the sample is triturated with caustic potash.

Detection of the Associated Alkaloids of Quinia (Cinchonia, Cinchonidine, and Quinidine.)—Ten grains of the sulphate of quinine are agitated in a narrow test-tube with a mixture consisting of one drachm by weight of pure ether and 10 drops of strong ammonia, and then allowed to rest. The liquid should after a while form two separate colourless and transparent layers, without any white or crystalline matter floating at the line of contact between the two strata; such an appearance would indicate the presence of the above associated alkaloids.

Ten grains of the sulphate of quinine are dissolved in a test-tube in one fluid drachm of distilled water and 8 or 10 drops of diluted sulphuric acid: then 2½ fluid drachms of ether, 3 drops of alcohol, and 40 drops of a solution of 1 part of caustic potash in 12 parts of water, are added. The test-tube is corked, agitated, and allowed to stand for 12 hours. When pure, the two fluid strata and the line of their contact will be clear and transparent; but even if traces of cinchonia and cinchonidine are present, they will be seen floating as a white cloud at the line of separation between the two strata. When cinchonidine is the only impurity it will appear at the line of contact as an oily-like stratum, consisting (when magnified) of minute amorphous particles, while cinchonia appears crystalline.

RED LEAD (Minium.)—This is a heavy orange-red powder, which becomes dark when heated, but regains its original colour on cooling. Heated on charcoal before the blow-pipe, it fuses, and is reduced to metallic globules.

Warm diluted nitric or acetic acid dissolves red lead only partially, leaving a brown residue, which is soluble on the addition of oxalic acid. A slight remaining turbidity is due to silicia acid, with which red oxide of lead is generally more or less contaminated.

Red lead is occasionally adulterated by *earthy substances*, such as *brick-dust*, *red ochre*, or *colcothar*. These impurities may be easily separated and their amount determined by boiling for some time a known weight of the red lead with sugar and water, with the addition of a small quantity of nitric acid; the binoxide of lead becomes thereby converted into protoxide, which dissolves in the acid; while the impurities remain insoluble, and may be separated by filtering. They are then washed, dried, and weighed.

As red lead is produced from litharge, it may contain all the impurities of the latter—namely, copper and silver. The presence of these substances in certain manufactures is very objectionable. This is especially the case with that of *crystal*, to which these oxides would impart a colour. The copper and silver may be detected and estimated exactly in the manner described in the article on *Litharge.*

RED OXIDE OF MERCURY. *See* MERCURY.

RED PRECIPITATE. *See* MERCURY.

RHUBARB.—Rhubarb is the root of a plant, of which there are several varieties. According to Dr. GOEBE, that rhubarb which is usually obtained in the druggists' and apothecaries' shops comes from China, and two species of Chinese rhubarb are known in trade. The one is termed Russian-Moscovian, or Siberian rhubarb; the other East Indian, Chinese, Danish, Dutch, &c., rhubarb.

Russian rhubarb is decidedly superior to East Indian. It is sound throughout; but it is mere fiction to assert that it may be distinguished by the peculiar form of the pieces, and that each single piece is pierced with holes, as is now and then pretended. In the chests, pieces large and small, flat and round, angular, pierced, some bearing the marks of the borer, and also some perfectly free from such marks, are mixed together. They are of a yellowish-red colour, and, when broken, present the well-known beautiful red-and-white marble appearance.

East India rhubarb is an assemblage of good and bad species, which even if they be sound and well preserved essentially differ from Russian, from the circumstance that they are not severally selected and pared again as are the Russian, and by which process all foreign matter is separated from the latter, together with the last remains of the cuticular substance.

Russian and Turkey rhubarb are identical articles; the best pieces, are, as above observed, in roundish lumps perforated with a hole, of a yellow colour outside, and when broken the inside has a mottled appearance. Good rhubarb should be firm, compact, and heavy; porous pieces are bad, or very inferior. The Chinese rhubarb is in flat pieces, seldom perforated, and its taste and odour are stronger than the other. It is also heavier, and when pulverized the powder is redder than that of the Russian rhubarb.

Rhubarb in the lump may be of bad quality, but is not subject to adulteration; this is not the case, however, when pulverized, for the powder is often mixed with gamboge. This sophistication may be readily detected by digesting a portion of the powder in ether, and pouring a few drops of the solution in water. If gamboge is present, a film of an opaque yellow colour will be observed floating on the surface, which on adding potash is dissolved with an intensely red colour.

RESIN (Colophonium).—Common resin is the residuum left in the still after the distillation of the different species of turpentine. If the distillation be carried to dryness, the resin is called common brown resin, or colophonium; in the contrary case it is yellow. The latter, or yellow resin is more soft or ductile, owing possibly to a small quantity of oil (resin-oil) which it retains; it is generally preferred and fetches a somewhat higher price, but it is seldom genuine, that is, frequently it is only the common brown resin which has been rendered yellow by an admixture of *water*. It is sufficient to boil the brown resin in water for some time, to convert it into yellow resin. Brown resin may thus imbibe a good deal of water in a few minutes. This adulteration is detected by exposing the yellow resin to a dry steam-heat for four or five hours; the genuine yellow resin remains unaltered, whilst that which has been mixed with water, by losing it returns to the state of brown resin.

ROCOU. *See* ANNOTTO.

ROMAN ALUM. *See* ALUM.

ROMAN VITRIOL. *See* SULPHATE OF COPPER.

ROUGE VEGETAL. *See* SAFFLOWER.

RUM. *See* BRANDY.

SAFFLOWER (Bastard Saffron, Saffranon, Carthamus).—Safflower is in flat cakes, and has the same appearance as saffron (from which, however, it is readily distinuished by simple inspection), but it has neither the taste nor odour of saffron.

Safflower contains two colouring matters, the one, which is yellow, is soluble in water; the other is red, and is extracted by carbonated alkali and citric acid.

The best safflower comes from India.

Good safflower should yield about 5 per cent. of red colouring matter; that which is met with in commerce in the liquid state, under the name of *extract of safflower*, or of *rouge végétal*, is generally mixed with finely pulverized talc. The red colour is extracted by first treating the safflower with cold water for a long time, in order to remove the yellow colour; the washing must be continued until the water passes colourless through a filter, and by treating it afterwards with alcohol the red colour is taken up, and may be isolated by evaporating the alcohol.

Or, after having removed the yellow colouring matter, the red colour may be extracted by macerating the safflower for an hour or two in its own weight of water, containing one-tenth of its weight of carbonate of sodium. The liquor, which should have a very brown colour, should be separated by squeezing the macerated safflower. Skeins of cotton should then be immersed in the liquor, and either lemon-juice, or a solution of citric acid, or of tartaric acid, being added in sufficient quantity to saturate the alkali, the liquor becomes red, and the red matter (carthamic acid) becomes soon fixed on the cotton, mixed with a little yellow colouring matter, which is subsequently removed by washing with water. The cotton thus treated should now be plunged into a bath, consisting of 20 parts of water and 2 parts of carbonate of soda; the cotton becomes immediately decolourized, and after having withdrawn and squeezed it, the red colour is precipitated by pouring lemon-juice into the said bath.

According to Dumas, the best method of testing safflower consists in taking a weighed sample of the safflower, washing it, and treating it with carbonate of sodium, as above said, precipitating the red colouring matter upon a known weight of skeins of cotton, and comparing the depth or intensity of the colour thus obtained with other portions of skeins of cotton of a same weight, dyed with a same weight of safflower, of a known quality, or with various samples of safflower, by which their comparative value may be ascertained.

SAFFRANON. *See* SAFFLOWER.

SAFFRON (Crocus).—Saffron is met with in commerce usually in round flat cakes (Persian saffron is in cakes of from nine to twelve inches in diameter, and from one half to three-quarters of an inch in thickness), which are formed of the stigmata and styles of the *Crocus sativus*, and contain a yellow colouring matter of great intensity, soluble in water. Saffron was originally imported from Persia, but it is now imported also from the Continent, and is prepared besides to a certain extent in England (Cambridgeshire). English saffron fetches a higher price. The filamentous petals of Persian saffron are much larger than those of European saffron, and they are at the same time darker and less imbued with flavour and colouring matter.

Good saffron is in long, flexible filaments of a red colour; it has a peculiar aromatic, agreeable, pungent odour, and a warm, somewhat bitter taste. The cakes should feel a little moist, of a close texture, and stain the fingers. That which contains but few *stamina*, which are easily recognised by their *anthera* and fine yellow colour, is the best. If the cakes have a brown or a pale yellow colour, feel unctuous or clammy, it is a sign that they are too old, or of bad quality, and should be rejected.

The price of saffron being always high, it is often adulterated to a great extent by an admixture of other plants, such as the petals of safflower, and other substances. This adulteration is detected by boiling a portion of the sample in water, and comparing the fibres with those of a portion of genuine saffron treated in the same manner.

The relative colouring power of the article may serve also as a criterion of its goodness. The experiment is performed with the colorimeter, exactly as described in the articles on *Madder* and *Indigo*.

Sometimes saffron which has been partially deprived of its colouring matter by infusion is dried and again offered for sale. Such saffron is recognizable by its dull red colour, which is uniform all through, and by its odour, which is much fainter. It scarcely imparts a yellow colour to water or saliva.

SAFFRON (Bastard). *See* SAFFLOWER.

SAL AMMONIAC (Muriate of Ammonia, Hydrochlorate of Ammonia, Chloride of Ammonium).—Sal ammoniac as met with in commerce is in the shape of colourless, translucent cakes, concave on one side and convex on the other: or in conical crystalline and white masses, hard and somewhat elastic, and consequently difficult to pulverize; this salt is inodorous, but has a bitter, acrid taste. When pure it crystallizes from its solution in octahedral, cubic, and plumose crystals. Its specific gravity is 1·45. It is unalterable, or very slightly deliquescent in the air; soluble in three parts of cold, and in about its own weight of boiling water; it is completely soluble in alcohol. In dissolving in water it produces cold; it is fused and volatilized without decomposition by heat.

Impurities.—Sal ammoniac generally contains but few impurities, which consist principally of a little *Sulphate of Ammonium*, *Chloride of Sodium*, *Sulphate of Sodium*, and *Sulphate of Magnesium.* Sometimes also it contains some *iron* or *lead*: the first being derived from the volatilization of a little chloride of iron, with which it combines to form a double chloride of iron and of ammonium. The second substance (the lead) comes from the contact of the cake of sal ammoniac with the lead dome or dever, against the sides of which it gradually condenses.

Sulphate of Ammonium is detected by dissolving a portion of the sal ammoniac in pure water, and testing the solution with one of chloride of barium, which (if sulphate of ammonium or any other soluble sulphate be present) will produce a white precipitate of sulphate of barium.

The other impurities are easily detected, because they are fixed; and therefore, by heating a portion of the sal ammoniac to redness in a platinum crucible, the impurities will be left behind.

If it be desired to identify the presence of iron and of lead, it may be done by dissolving a portion of the sal ammoniac in water, and dividing it into two portions, to one of which a little nitric acid is first added; and if by pouring a drop or two of ferrocyanide of potassium a blue precipitate is produced, it indicates the presence of iron. The presence of lead is detected by passing a current of sulphuretted hydrogen through the second portion, which produces a black precipitate of sulphide of lead.

The aqueous solution of pure sal ammoniac should have no action whatever upon test-papers; it should not be precipitated or discoloured by either sulphuretted hydrogen or hydrosulphuret of ammonia, nor by a solution of phosphate of sodium and ammonia. It should completely volatilise by ignition, and if before the complete volatilization of the salt an abundant residuum of charcoal be observed, it is a proof of the presence of organic matter.

SAL PRUNELLA. *See* NITRE.

SALTPETRE. *See* NITRATE OF POTASSIUM.

SALT (COMMON). *See* CHLORIDE OF SODIUM.

SEIDLITZ SALTS. *See* SULPHATE OF MAGNESIUM.

SEED-LAC. *See* SHELL-LAC.

SHELLAC (Gum-lac).—Lac, stick-lac, seed-lac, and shell-lac, are the names of a substance obtained from incrustations made by an insect (*Coccus lacca*) similar to the cochineal on the branches and twigs of several trees in India. The lac is formed by the insect into cells, somewhat similar to a honey-comb, but differently arranged, and in which the insect itself is generally found entire; and owing to the presence of which stick-lac may be made to yield, by proper treatment, a red dye nearly, if not quite as bright as that obtained from cochineal, and more permanent.

Lac containing fragments of branches and other detritus is called stick-lac. The best stick-lac, when held against the light, is semi-transparent.

The colouring matter is extracted from stick-lac by grinding or pounding it into coarse powder, which, after treatment with water, constitutes the *seed-lac* of commerce.

Shellac is made from either stick-lac or shellac, in the following manner:—The seed-lac, or stick-lac, previously reduced into coarse powder, is mixed with about 15 per cent. of an Indian resin called dammar, but more frequently, and we might say almost generally, with common yellow resin, exported from England to India, and the mixture is then put into a small calico bag, about 2 inches in diameter, and about 2 feet or 2½ feet in length. The bag is held over a charcoal fire, and as soon as the contents have sufficiently softened, the bag is twisted, and the lac, oozing through the meshes of the calico, is scraped off with the blade of a long knife, and whilst yet hot and soft it is scraped from the knife against the stem of a plantain-tree, and flattened thereon with the stalk of a leaf of the same tree; when cold, the shell or plate of lac is easily detached from the stem of the tree, and this constitutes shellac. The thinness of shellac depends on the degree of pressure and of fluidity of the lac, and the shellac exhibits generally on one side the marks of the stem of the tree on which it has been flattened.

Shellac is packed in India in strong wooden chests, but during the journey to England the temperature in the hold of the ship is often sufficient to soften the pieces of shellac, which then adhere together, so as to convert the contents of a chest into one solid lump of lac. Shellac which has thus agglomerated is known under the name of *lump-lac.* The quality and usefulness of the lac is not thereby deteriorated or diminished in the slightest degree, though the commercial value of such lac is singularly depreciated, sometimes to a considerable extent.

Thin, transparent, and *orange-coloured* shellac is the best; the next quality, which is almost as highly prized, is *ruby shellac;* then comes the *liver shellac,* so called from its brownish colour. Ruby shellac is much harder than either orange or liver shellac, and contains much less dammar or resin; it makes, accordingly, a harder varnish, of a bright mahogany colour. Orange shellac contains a large portion of dammar, and fuses almost like wax.

When shellac breaks with a dull fracture and with ragged edges, it has been overdosed with resin. Good shellac, on breaking, should snap with a clear sound, and the edges should have a smooth, horny appearance, like strong glue. When a handful of shellac is poured from one hand to the other, or back again into the chest, the noise produced should be clear and sharp. The thickness or thinness of shellac is no criterion, either of good or of bad quality; nevertheless, orange shellac, from its greater fusibility, is generally in exceedingly thin flakes, and the best *ruby shellac* is in roundish pieces about 2½ inches in diameter, and is then known under the name of *button shellac*; it exhibits also the marks of the plaintain-tree on one side, which orange shellac seldom does. *Liver shellac* is in thicker flakes than orange shellac, but is thinner than *button shellac.*

Stick-lac, seed-lac (except the impurities, such as fragments of branches, and of insects), *lump*, and *shellac*, should completely dissolve in alcohol, naphtha, and in alkaline water. These criteria are of great importance; for stick-lac, and more especially seed-lac, are often adulterated to an incredible extent.

SILK. *See* COTTON.

SILVER.—Silver is the whitest of all metals. When it has been precipitated from a solution by a metallic bar—one of copper, for example—it is in the state of a spongy mass, consisting of crystalline grains, which may be rendered very cohesive by pressure or hammering. When melted and cooled slowly, it crystallizes in voluminous octahedrons, or in cubes. Silver is odourless and tasteless, a little harder than gold, but less so than copper; next to gold, it is the most ductile and the most malleable of metals. Silver melts at about 1873° Fahr. When fused in close vessels it does not volatilize, but when exposed to a current of air or of gas it does rapidly. Pure silver, when in a state of fusion, may absorb twenty-two times its weight of oxygen, but a small proportion of copper is sufficient to prevent this absorption. The silver, on cooling, abandons the oxygen, and in so doing shoots up and spurts, producing a rough surface, or a sort of metallic vegetation. The analysis of the alloys of silver is made either by cupellation, or in the humid way.

Estimation of Silver in Alloys (wet method).—The analysis of alloys of silver by a solution of chloride of sodium may be effected in three different ways:—1. The silver may be precipitated by an excess of the alkaline chloride, the weight of the chloride of silver produced indicating the amount of silver. 2. The quantity of chloride of sodium in a given weight of its aqueous solution being known, the amount of silver in the alloy may be ascertained by observing the weight of the alkaline chloride required to precipitate it completely. 3. The quantity of chloride of sodium in a given volume of its aqueous solution being known, the amount of silver in the alloy may be ascertained by observing the volume of the solution of alkaline chloride required to precipitate it. The last of these methods was proposed by GAY-LUSSAC in 1829, and as it is one of great simplicity and accuracy it is generally adopted in the British, Continental, and American mints for the assay of bars and coins of silver. The process is conducted in the following manner (PELOUSE and FREMY):—

(a.) *Preparation of Pure Silver.*—A certain quantity of ordinary silver is dissolved in nitric acid; should any residue remain, it is separated by decantation, the solution is diluted with water and precipitated by slight excess of chloride of sodium; the resulting chloride of silver having been well washed and dried, is reduced at a red-heat in a Hessian crucible with a mixture of chalk and charcoal, the proportions being 70·4 parts of chalk, and 4·2 parts of charcoal for every 100 parts of dry chloride of silver.

The reduced silver forms a button at the bottom of the crucible; it is removed, well washed, re-dissolved in nitric acid, the solution again precipitated by common salt, and the chloride again reduced by chalk and charcoal; the metal is now perfectly pure. It should be reduced to a granular state, or rolled into thin plates to facilitate its solution in nitric acid.

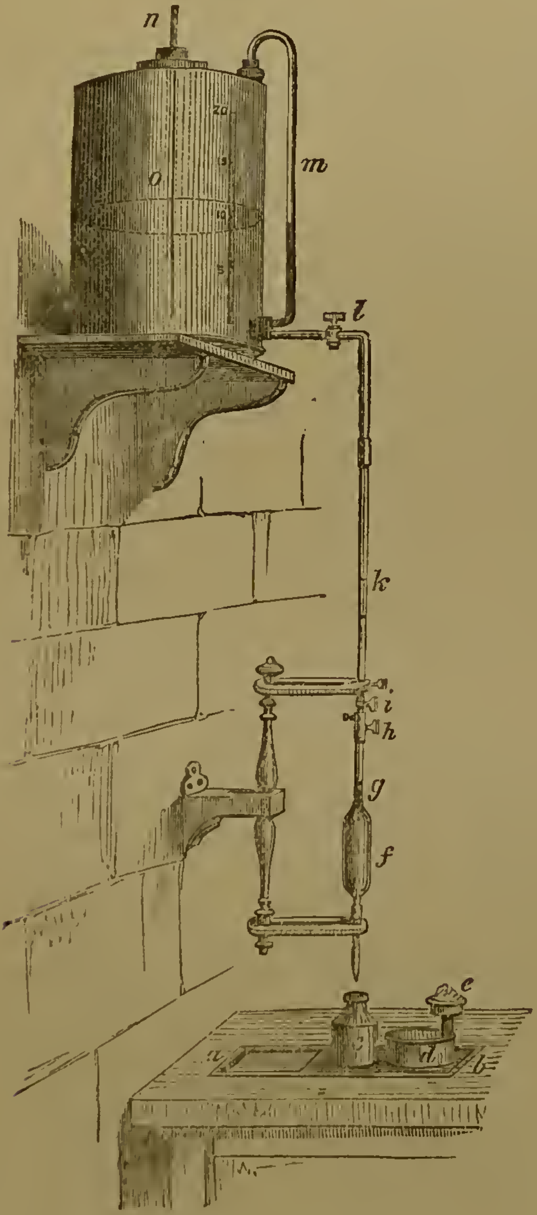
(b.) *Preparation of a Standard or Normal Solution of Chloride of Sodium.*—A normal solution of chloride of sodium may be prepared by dissolving 5·414 grammes of the pure salt in 1 litre of distilled water at 15° C.; a décilitre (100 cubic centimètres) of this solution will precipitate exactly 1 *gramme* of pure silver.

It is better, however, to prepare the normal liquor from ordinary culinary salt. For this purpose 200 or 300 grammes should be dissolved in about 2 litres of water; a few grammes of the solution should be evaporated to ascertain the exact amount of salt it contains, and the solution should then be diluted with such a quantity of distilled water as would be required, supposing the salt to be pure. 1 gramme of the pure silver is dissolved in pure nitric acid, and the solution precipitated with the proper precautions by 100 cubic centimètres of the saline solution; but as the salt is not pure, the quantity will not be found sufficient to effect the complete precipitation of the silver, and it will be necessary to add a certain number of cubic centimètres of a *decinormal* saline solution, the exact composition of which is known. The volume of this solution which has been required to complete the precipitation of the silver is noted, and a calculation is made to ascertain how much of it must be added to the first solution to render it normal. The experiment should be repeated two or three times, to ensure accuracy.

It is not, however, absolutely necessary that 100 cubic centimètres of the saline solution should precipitate exactly a gramme of pure silver; it suffices if it approximates very closely, and that the exact quantity of silver precipitated be known.

(c.) *Preparation of the Decinormal Saline Solution.*—100 cubic centimètres of the *normal* solution are poured into a flask of the capacity of 1 litre, which is then filled up with distilled water and well mixed; it is evident that a litre, or 1,000 cubic centimètres, of this solution will be required to precipitate 1 gramme of pure silver; and that one-thousandth part, or 1 cubic centi-

FIG. 24.



mètre, will precipitate one-thousandth part of a gramme, or 1 milligramme of silver.

(d.) *Preparation of the Decinormal Solution of Silver.*—One gramme of the pure metal is dissolved in 5 or 6 grammes of pure nitric acid, and the solution diluted with distilled water to exactly the volume of 1 litre. The *decinormal* silver solution and the *decinormal* saline solution are thus prepared of such strengths, that on mixing together equal volumes of each neither nitrate of silver nor chloride of sodium remain in the liquor, but nitrate of soda is in solution, and chloride of silver precipitated.

In laboratories where the wet assay of silver alloys is constantly going on, large quantities of the normal saline solution are prepared at once, and the pipette is arranged as a fixture in the manner represented in Fig. 24, where *o* represents the reservoir containing the normal saline solution, and *n* a tube through which air is admitted when the apparatus is in use. The solution is delivered from the reservoir through the bent tube *l*, furnished with a stop-cock. The pipette *g f* is placed in communication with the bent delivery-tube by the tube *k*, in which a thermometer is inserted; *i* is a stopcock which serves to establish a communication between the tube *l k* and the pipette. The apparatus *a b* is employed to facilitate the exact emptying of the pipette, the tray *c d* slides backwards and forwards between two grooves, its motion in either direction being limited by the stops *a* and *b*. As seen in the figure, the assay-bottle *c* is immediately under the lower extremity of the pipette, from which the liquor can be delivered without wetting the neck or sides of the bottle; *d* is a small vessel for receiving the excess of the saline solution, and *e* is a small sponge so adjusted that when the tray is slid along the groove till it is stopped by *a*, the sponge just touches the lower extremity of the pipette. In order to fill the pipette, its lower aperture is closed by the finger, and the stopcocks *l* and *i* being opened, the solution enters from the reservoir, the air escaping through an aperture in the plug of the lower part of plug *h*. The pipette being filled, and the aperture closed, the finger is removed, and the sponge brought in contact with its point; the plug *h* is now gently relaxed, and the liquor allowed to flow from the pipette until the mark *g* is reached; the plug is then closed, and the last drop having been removed by the sponge, the burette remains filled with exactly 100 cubic centimètres of the saline solution.

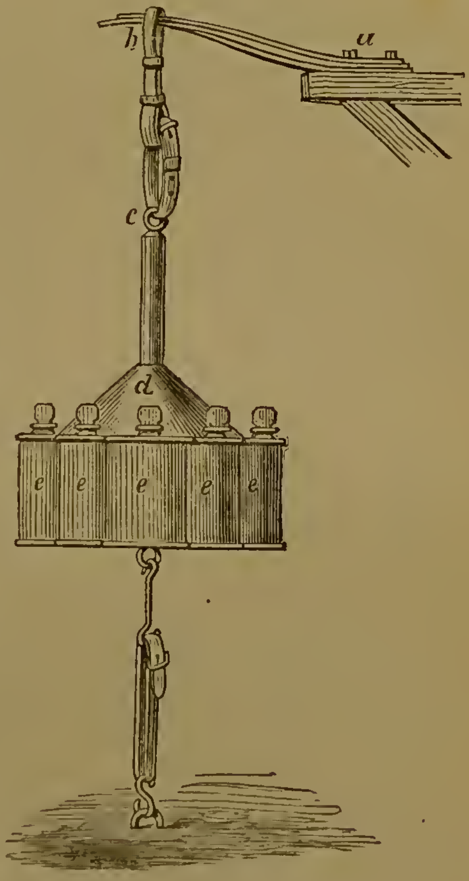
Previous to applying this process to the analysis of silver alloys, it is neccssary to know approximately the value of the assay; that is, to operate upon a quantity containing nearly one gramme of silver; a tentative experiment on a gramme of the alloy with the normal saline solution will give the requisite information on this point.

Let us suppose, by way of illustration, that a piece of French silver coin is to be examined, which, in order to be of the standard quality as prescribed by law, should contain $\frac{897}{1000}$ths of silver. The quantity that should be taken to represent 1 gramme of silver is formed by the proportion—

$$827 : 1000 :: 1000 : x$$
$$x = 1\cdot115.$$

1·115 grm. of the alloy are, therefore, dissolved with the aid of a gentle heat in 5 or 6 cubic centimètres of pure nitric acid, the solution is transferred to the bottle *c*, Fig. 24, and the charge from the pipette delivered into it. The bottle is closed with its stopper, and briskly agitated for two or three minutes; if only one or two assays are being made, this may be done with the hand, but when several samples are being operated upon, the *agitator*, Fig. 25, is employed. This consists of a frame *d*, provided with a series of compartments *e e e*, &c., each of which will hold exactly one of the bottles; the frame is suspended from the steel spring *a b*, between two strong springs of vulcanized indiarubber. The stoppers of the bottles having been well secured, the apparatus is grasped by the handle *c d*, and briskly agitated for two or three minutes; the chloride of silver is soon completely precipitated, leaving the supernatant fluid quite clear. One cubic centimètre of the *deci-normal* saline liquor is now delivered into the bottle from a small pipette; this pipette

FIG. 25.



is a small tube open at both ends, the lower aperture being considerably contracted; it has two marks upon it corresponding to 1 and 2 cubic centimètres; it passes through the cork, and nearly to the bottom of the bottle containing the deci-normal saline liquor, so that the requisite quantity can be easily withdrawn, by applying the finger to the upper end, then removing it from the bottle, and allowing the liquor to drop out from the lower aperture by relaxing the finger until the mark indicating 1 cubic centimètre has been exactly reached. Should the solution still contain silver, it is revealed by the formation of a white cloud; hereupon the bottle is again agitated, and a second cubic centimètre of the deci-normal saline solution introduced. Suppose that 3 cubic centimètres have in this way been added, and that the fourth no longer produces a white cloud, the question arises, was the whole of the third cubic centimètre required or only part of it? But as this question cannot be decided, one-half of the third cubic centimètre is assumed as the real quantity; the error arising from this arbitrary measure cannot amount to more than half a millimètre, since 1 cubic centimètre of the deci-normal saline liquor corresponds to 1 milligramme of silver. The result of the assay then is this:—(1) 100 cubic centimètres of the normal saline liquor, equivalent to 1·000 gr. of silver; (2) 2·5 cubic centimètres of the deci-normal saline liquor, equivalent to 2·5 milligrammes of silver: the quantity of alloy submitted to analysis contains therefore 1·000 gr. + 0·0025 gr. = 1·0025 gr. of silver. The standard of the alloy is therefore found by the following proportion:—

$$1{\cdot}115 : 1000 :: 1000 : x$$

$$x = 0{\cdot}899, \text{ or the standard of the alloy is } \frac{899}{1000}.$$

Suppose, however, that *no* white cloud has arisen after the introduction of the first cubic centimètre of the deci-normal solution; this shows that the whole of the silver has been precipitated by the 100 cubic centimètres of the normal saline liquor, and that quantity has probably been too much; to ascertain this, the cubic centimètre of the deci-normal *saline* solution which has just been added must be neutralized by 1 cubic centimètre of the deci-normal *silver* solution, and the liquor must be agitated till clear; the operator then adds successive cubic centimètres of the deci-normal silver solution until a white cloud is no longer produced. Let us suppose that a cloud ceases to make its appearance on the addition of the fourth cubic centimètre, then, as before, one-half of the third cubic centimètre is taken as representing the real quantity that has sufficed; the 1·115 gramme of alloy contains therefore $1{\cdot}0050 - 0{\cdot}0025 = 0{\cdot}9975$ gramme of silver, and the standard is formed by the proportion—

$$1{\cdot}115 : 1000 :: 1000 : x$$

$x = 0{\cdot}8946$, which is below the legal French standard, viz. 0·897.

Dilatations and contractions are occasioned in the volume of the normal saline liquor by variations in temperature, and M. GAY-LUSSAC constructed a table of corrections to be applied. It is better, however, when a series of assays is about to be made, to make at the same time a standard assay with a gramme of pure silver; the exact value of the normal solution is thus ascertained, and all the assays made on the same day must be corrected in accordance with the divergence from the true value of the liquor indicated by the test experiment.

If the operator is working with English weights and measures, the solution of common salt should be made of such a strength that 1000 grain-measures of it precipitate exactly 10 grains of silver, and the decimal solution of silver should be prepared by dissolving 10 grains of pure silver in nitric acid, and diluting it with distilled water till the solution occupies the bulk of 10,000 grain-measures of water; each 10 grain-measures of this solution will therefore contain 0·01 grain of silver.

The only metal the presence of which interferes with the accuracy of this process is *mercury*—a metal not likely to be met with in silver alloys; if present, however, it would be precipitated by the chloride of sodium together with chloride of silver in the form of *calomel*. To avoid this inconvenience LEVOL recommends to supersaturate the nitric solution with caustic ammonia, then to add the test-liquor, and afterwards to supersaturate the excess of ammonia with acetic acid; he states that by this modification he is able, either with the presence or absence of copper, to estimate accurately silver containing a tenth part its weight of mercury. GAY-LUSSAC simplifies this process by adding to the nitric solution of the alloy the ammonia and acetic acid at one and the same time, but in sufficient quantity to saturate the whole of the nitric acid, both that in combination with the silver and that in the free state. He finds acetate of sodium to answer quite as well as acetate of ammonium.

Estimation of Silver in Alloys (dry process).—*Cupellation.*—This method, which is the one usually adopted at Goldsmiths' Hall, and by refiners, is founded on the property possessed by silver of being unoxidizable, and nearly fixed, at a red-heat; whilst copper in the presence of lead oxidizes, and forms with the oxide of lead a fusible glass, which passes into, and is absorbed by the cupel, the silver being retained, as it were, on a filter, in the form of a bright globule or button.

The *cupel*, which is best made of a mixture of finely levigated ashes of birch-wood and calcined bones, is thus prepared: the ash, slightly moistened, is laid in a brass mould somewhat deeper than that of the cupel intended to be made; in this is placed a curved and polished steel pestle, which is then struck smartly with a hammer. The operator must be careful to put as much ash into the mould as is required to make the cupel *at once*; it is otherwise apt to separate in layers when it comes to be heated. The little vessel thus made is dried with great care, and heated to redness before it is used. One part, by weight, of the cupel absorbs during the process of cupellation the oxide formed by two parts of lead. The assayist is thus furnished with a guide to the size of the cupel required for any particular experiment.

The proportion of lead required varies with that of the copper in the alloys; it is necessary therefore, before proceeding with a definite experiment, to determine approximately the *standard* or *fineness* of the silver. In the case of a piece of coin this is generally tolerably well known, but in all cases the fineness of the silver should be ascertained by a cupellation experiment with 0·100 gr. of the alloy and 1 gr. of lead; the weight of the button obtained furnishes a sufficiently close approximation, and from this preliminary trial the quantity of lead which should be added is ascertained by reference to the following table constructed by M. D'Arcet. The quantity of alloy usually employed is 1 gramme, the weight of the button in milligrammes indicates the standard of the alloy: thus a button weighing 0 gr. 900 milligrammes represents an alloy of $\frac{900}{1000}$.

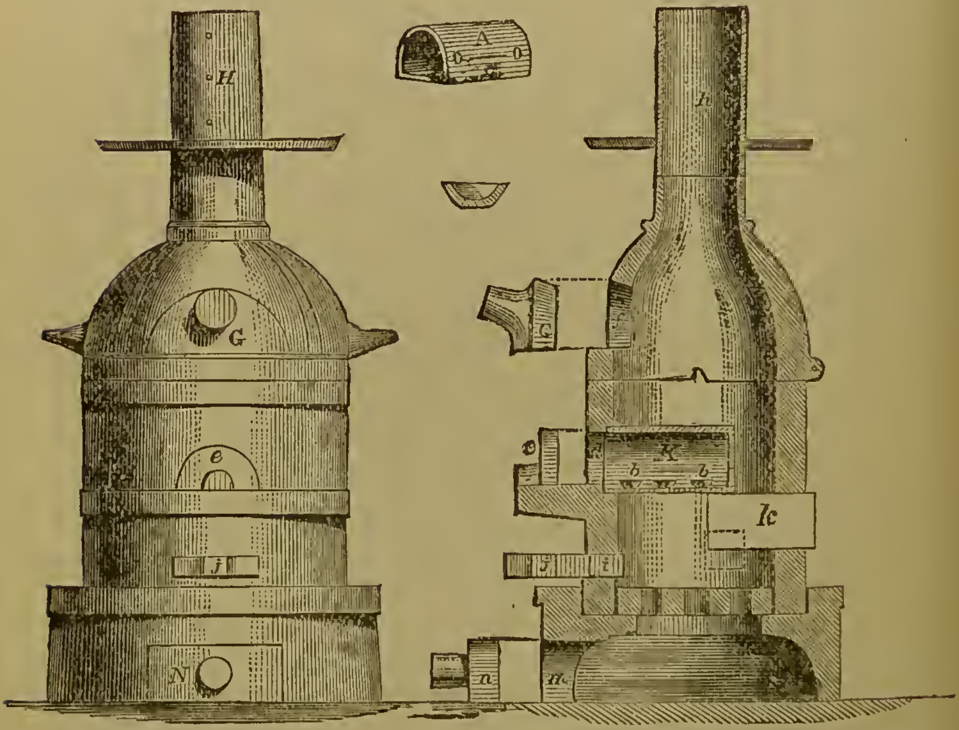
Table showing the Quantity of Lead required for the Cupellation of various Alloys of Silver and Copper.

Standard of Silver	Amount of Copper alloyed	Quantity of Lead necessary	Quantity of Lead in relation to that of Copper
1000	0	$\frac{3}{10}$	—
950	50	3	60 to 1
900	100	7	70 to 1
800	200	10	50 to 1
700	300	12	40 to 1
600	400	14	35 to 1
500	500	16 to 17	32 to 1
400	600	16 to 17	27 to 1
300	700	16 to 17	23 to 1
200	800	16 to 17	20 to 1
100	900	16 to 17	18 to 1
Pure copper	1000	16 to 17	16 to 1

Example.—Suppose a piece of silver of the approximative fineness of $\frac{900}{1000}$ is to be analysed. The quantity of lead indicated in the Table, viz. 7 grammes, is placed in the cupel, which is then introduced into the muffle, and heated to bright redness in the cupel furnace. When the lead is melted, and its surface brilliant, 1 gramme of the alloy enveloped in a piece of *pure* sheet lead is introduced into the cupel; it soon enters into fusion, and the surface of the liquid mass, which is at first plane, becomes by degrees convex; in appearance it is now like a drop of oil. The fused oxide of lead is absorbed rapidly by the cupel, and a portion is volatilized and makes its escape from the muffle in the form of fumes; when the volume of the alloy is reduced to about two-thirds, the cupel is advanced to the mouth of the muffle; the surface of the button soon loses its brilliancy, and iridescent bands appear on its surface, which are occasioned by very thin layers of oxide of lead. The object of advancing the cupel to the mouth of the muffle, is to reduce the temperature of the button, which at this period becomes agitated with a rapid circular movement; this suddenly ceases, and the button having for a moment emitted a bright flash of light, technically called *fulguration* or *coruscation*, becomes white and fixed. The button should at the moment of brightening be covered with another cupel which has been kept hot for the purpose; a portion of the metal may otherwise be lost by dispersion, from *sprouting* or *spitting*. This phenomenon appears to arise from the sudden escape of the oxygen, which the silver had mechanically absorbed while in the melted state: if the button has been cooled too rapidly, a crust is formed over the surface, while the interior portion remains fluid, and upon this solidifying, the crust is ruptured by the sudden expansion of the metal, and little tubes or globules of the metal are expelled by the sudden escape of the gas. The cupel, still covered, is now removed from the muffle, and when cold the globule is detached, brushed, and weighed. If the assay has been a good one, it adheres but loosely to the cupel, and its surface is clean, brilliant, and convex; but if it has been too strongly heated, it is removed with difficulty, and its surface is dull and irregular. The adherence of the button to the cupel, and the flatness of its surface, may also arise from a deficiency of lead.

In Fig. 26, A is the muffle, on each side of which is a slit *o o*; the size of this muffle is in proportion to that of the furnace; one of a convenient size should be capable of containing six or eight cupels. The muffle when introduced into the furnace is so arranged that while its closed end is supported by a shelf of refractory brick *k*, its open end corresponds exactly with the aperture *d* of the furnace, to the sides of which it is luted by a little moistened fire-clay. The fuel (charcoal or coke) is supplied through the aperture *f*, which during the operation is closed by the door G. The interior of the muffle is in this way constantly traversed by a current of air, and the draught of the furnace is increased by the tall chimney H. The furnace having been lighted by introducing ignited charcoal by the opening, *i*, and all the apertures except that of the ash-pit having been closed, the muffle is allowed to get red hot; the cupels which have been previously drying round the ledge of the chimney are then placed by a pair of tongs on the floor of the muffle, on which a small quantity of pounded bone-ash has been strewed; the opening *d* is now closed; the cupels are soon raised to the temperature of the muffle, and when this is the case the door is removed, and the assay dropped carefully into the cupels by a pair of light steel tongs.

FIG. 26.



From a series of experiments made first by TILLET, and confirmed and extended by D'ARCET, the following conclusions may be drawn:—

(1.) That by the process of cupellation the amount of silver is always slightly under-estimated, in consequence of a portion being volatilized, and a portion being absorbed by the cupel.

(2.) That the button is not pure silver, but contains both lead and copper; a wet analysis shows that as an average 1,000 parts of the button contain four parts of foreign metals.

(3.) The more copper the alloy contains, the larger the quantity of lead required; this, however, is only applicable to alloys the standard of which is above 500. Copper containing a few thousandths of silver only does not require more lead than an equal weight of an alloy of 500.

Bismuth acts in cupellation in the same manner as lead, and M. CLAUDET has drawn up a Table showing the proportions that should be used in different standards of alloys, but no application of these facts appears to have hitherto been made.

To estimate the amount of loss during the operation of cupellation, recourse is sometimes had to a 'Table of errors,' which, however, cannot be made exact, because such a Table implies certain invariable conditions which in practice cannot always be complied with. It is better to use with each set of assays a *check* or *proof*, that is, to make an assay with pure silver. The proof is placed in the muffle by the side of the assays; *e.g.* suppose an assay has to be made of a piece of coin the approximative standard of which is $\frac{950}{1000}$; 950 milligrammes of pure silver and 50 of copper are placed in a cupel and introduced into the muffle by the side of the alloy. Suppose that after cupellation the proof has lost two milligrammes, this quantity must be deducted from the weight of the button furnished by the alloy. These proofs are especially useful when the alloy contains *gold*, *platinum*, or *palladium*, as these metals tend to occasion an overweight in the button.

Some experiments were made by Mr. HAMLEY ('Chem. Gaz.' vol. xv. p. 185), to ascertain whether the loss of silver by cupellation is the same when varying quantities are employed with a constant ratio of lead, and also to find the loss of silver when cupelled with a gradually increasing ratio of lead. The conclusions drawn from the experiments are—1. That according to the decrease in weight of the silver cupelled, so the loss of that metal very slightly increases, provided the ratio of lead employed be constant. 2. That an increasing ratio of lead produces an increasing loss of silver.

According to FIELD ('Chem. News,' vol. i. p. 277), the presence of *copper* exercises a material influence upon the loss of silver in the process of cupellation, in the estimation of that metal; when it exists as a double sulphide with copper, the loss is very apparent, so much so, indeed, that in the assay of these double sulphides, FIELD found it necessary to abandon the usual method and to adopt the following:—The finely powdered mineral is digested in strong nitric acid until the sulphur is yellow; the solution is somewhat largely diluted with water, and one or two drops of hydrochloric acid added. After heating gently, and allowing the supernatant liquor to become clear, it is filtered. The residue on the filter consists of earthy insoluble matter and chloride of silver. It is dried, and the greater part mixed in a mortar with carbonate of sodium, a small quantity of litharge, and a few grains of bitartrate of potassium. About half the mixture is put in a crucible, and the filter is then folded up and placed upon the powder, the remainder of which is now introduced, and the whole covered with a little fused borax. The crucible is now introduced into the furnace; an argentiferous button of lead is obtained, which is cupelled in the usual manner.

Among the various other methods of separating *silver* from *copper*, *two* may be specially noticed. *The first* consists in fusing the argentiferous copper with 2½ parts of lead, and cooling the fused mass in thick round cakes. These cakes are then introduced into a furnace of peculiar construction, and the heat is raised sufficiently high to fuse the alloy of silver and lead, but not to fuse the copper. On cooling, the whole of the silver is found combined with the lead, from which it is separated by cupellation. *The second method* consists in dissolving the argentiferous copper in sulphuric acid, in a platinum vessel, and precipitating the silver from the solution by means of plates of copper; the precipitated copper, which is in the form of a grey metallic powder, is washed and fused with a mixture of nitre and borax; it is thus purified from the copper which may have been precipitated with it. The method has two advantages; *first*, the copper is recovered in a marketable form (that of blue vitrol); and *second*, the gold amounting to from $\frac{1}{1000}$ to $\frac{1}{120}$th part, is saved, this metal remaining undissolved by the sulphuric acid.

To estimate the amount of silver in a compound (commercial lead, for example), PISANI avails himself of the fact that iodide of starch is decolorized when poured into solutions of some salts, whilst in others it retains its blue colour. The decolorization is produced by *silver*, *mercury*, the protosalts of *tin*, *antimony*, *arsenic*, *iron*, and *manganese*, and perchloride of *gold*. The salts of *lead* and *copper* have no action on it. In order, therefore, to estimate the amount of silver in a compound, a standard solution of iodide of starch is dropped into the solution until the last drop is undecomposed, and causes a blue tint to remain in the liquid. Instead of forming a standard solution of iodide of starch, FIELD dissolves iodine in iodide of potassium, and drops it into the solution of the silver salt to which a little starch-water has previously been added. The silver compound is dissolved in nitric acid, gently evaporated nearly to dryness, a slight excess of carbonate of sodium introduced, and the carbonate of silver brought into solution by very weak acetic acid; a few drops of clear starch-water are added, and the ioduretted iodide of potassium dropped in from a burette. When the two liquids meet, a bright blue ring is formed, which immediately disappears on agitation, yellow iodide of silver being precipitated. When a permanent blue tinge is produced, no more silver exists in the solution. Three burettes are employed; in the first one, each division corresponds to $\frac{1}{10}$ of a grain of silver, in the second to $\frac{1}{100}$, and in the third to $\frac{1}{1000}$. When it is evident that the greater part of the silver has been precipitated by the solution from the first burette, a small quantity from the second is introduced, and the last traces are thrown down by the third. No difficulty is experienced in compounds of *silver* and *tin*, but the presence of *mercury* entirely vitiates the results, as a salt of this metal decomposes the starch compound with great facility.

SILVER (Amalgamated). *See* GERMAN SILVER.

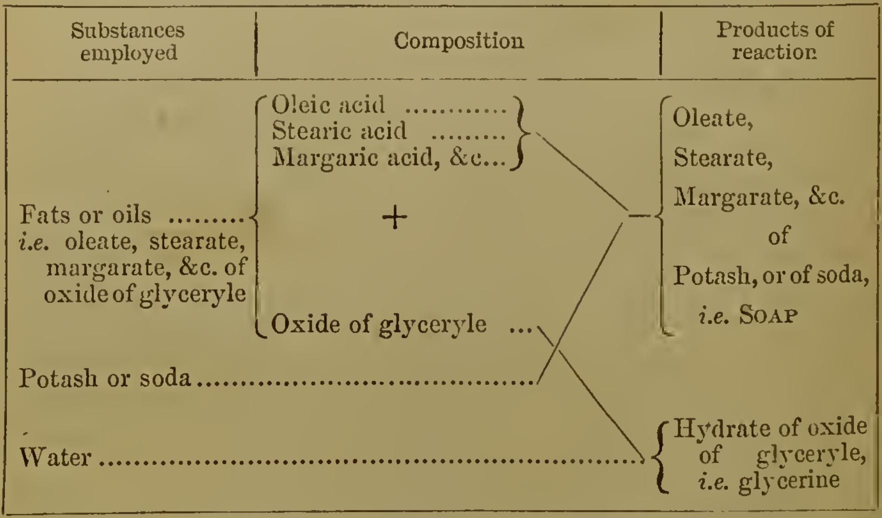
SIMILOR. *See* BRASS.

SMALT (Azure Blue).—Smalt is a blue glass, which is prepared by fusing zaffre with colourless glass, or by calcining a mixture of equal parts of roasted cobalt ore, pearlash, and ground flints; the result is a blue glass, which, whilst red-hot, is thrown into cold water, and afterwards reduced into impalpable powder. Smalt is much employed in the potteries, in the manufacture of paper, and for other purposes.

Smalt is sometimes adulterated with chalk; this fraud, however, may be immediately detected by pouring a little hydrochloric acid upon it, which in that case will produce an effervescence. The analysis of smalt is performed exactly like that of glass (see *Glass*).

SOAP.—Soap is a most important article of manufacture and of commerce; it is a compound resulting from the combination of certain constituents derived from fats, oils, grease, and rosin, with certain salifiable bases, which in detergent soaps are potash or soda.

Oils and fats consist chiefly of three principles, of different consistency, the one more fluid than the two others. The first is called oleine, and is always liquid at the ordinary temperature; the two others are called stearine and margarine. These substances, chemically considered, have been regarded as salts, or combinations of an oxide with an acid, that is to say, are the result of the combination of stearic, margaric, oleic acid, &c., with the oxide of a compound radical, called *glyceryle* (sweet principle of oils). Stearine being therefore a combination of stearic acid with oxide of glyceryle, is a stearate of oxide of glyceryle; oleine is oelic acid + oxide of glyceryle, or oleate of oxide of glyceryle; margarine is margaric acid + oxide of glyceryle, or margarate of oxide of glyceryle, &c. Glycerine is a combination of oxide of glyceryle with water, or hydrate of oxide of glyceryle. Now, when these substances (namely, oleine, stearine, margarine, &c., or the fats or oils which they constitute) are treated by a solution of potash or of soda, their constituents react upon each other, and combine with the potash or soda to form soap. The following diagram exhibits this interesting reaction :—



The soap made with soda is hard, that made with potash is soft, and the degree of hardness or of softness depends moreover upon the quantity of stearine and margarine, or of oleine contained in the fat or oil employed. Hence the more oleine a fatty matter contains relatively to the stearine and margarine, the softer the soap made with it will be, and *vice versâ.* The softest soap would therefore be that made altogether with oleine and potash (oleate of potassium); the hardest would be that made with stearine and soda (stearate of sodium). Ordinary soaps, however, are mixtures of these fatty acids in variable quantities, according to the species of fat or oil employed. The oils or fatty substances employed for the manufacture of soap are olive-oil, tallow, lard, hempseed-oil, oil of almonds, oil of linseed, horse-oil or fat, rape-oil, poppy-oil, train-oil, cod-oil, and other fish-oils, cocoa-nut oil, palm-oil, kitchen and bone fat, resin. This last substance (resin) always makes, even with soda, a soft, viscid kind of soap, owing to its great affinity for water; so that, even after having been artificially dried, the soap made with it deliquesces by exposure, and returns to the soft state.

On the Continent olive-oil, mixed with about one-fifth of rape-oil, is principally used for making hard soap. This addition of rape-oil is always resorted to because olive-oil alone yields a soap so hard and so compact that it dissolves only with difficulty and slowly in water, which is not the case with rape-oil, or other oils of a similar nature—that is, oils which become thick and viscid by exposure—experience having taught that the oils which turn viscid the soonest by exposure yield with soda a softer soap than that made with oils which, like olive-oil, remain limpid for a long period under the influence of the air. The admixture of rape-oil has therefore the effect of modifying the degree of hardness of the soap. In England tallow is used instead of olive-oil; the soap resulting from its treatment with soda is known under the name of *curd soap.*

There are too kinds of hard soaps, besides curd soap above alluded to, namely, mottled soap and yellow *fitted* soap.

Mottled soap has a marbled or streaky appearance; that is to say, veins of a bluish or slate colour pervade its mass, which is white or whitish; the size and number of these veins depend on the more or less rapid cooling of the soap after it has been *cleansed,* that is, transferred from the copper to the frames. The blue or slate colour of these streaks is chiefly due to the presence of an alumino-ferruginous soap interposed in the mass, and frequently, also, to that of sulphide of iron, which is produced by the reaction of the alkaline sulphides contained in the soda-ley upon the iron, derived from the iron, copper, and utensils employed in this manufacture, or which even is at times introduced purposely in the state of solution of protosulphate of iron. The veins gradually disappear, by keeping, from the surface to the centre, by the oxidation of the sulphide of iron. A well manufactured mottled soap cannot contain more than 33, 34, or at most 36 per cent. of water. It is evident indeed that the mottling being due to the presence of sulphide of iron held in the state partly of demi-solution and of suspension, the addition of water would cause the colouring substances to subside, and a white, uncoloured, or *fitted* soap would be the result. This addition of water, which is technically called *fitting,* is made when the object of the manufacturer is to obtain a unicoloured yellow or white soap. After *fitting,* the soap contains, therefore, an additional quantity of water, which sometimes amounts to 55 per cent., and which is sold at the price of soap. The interest of the consumer is therefore clearly to buy *mottled soap* in preference to yellow or white soap; the mottling is a sure criterion of genuineness, for the addition of water, or of any other substance, would infallibly destroy the mottling.

Besides water, soap is often adulterated by gelatine (known as bone-soap), which is made by adding to the soap a solution of disintegrated bones, sinews, skins, hoofs, sprats, or other cheap fish, in strong caustic soda; also by dextrine, potato-starch, pumice-stone, silica, plaster, clay, salt, chalk, carbonate of sodium, &c., &c., and by fats of another or inferior kind than those from which they are represented to have been made.

The impurities may be detected, and their amount ascertained, in the following manner:—

Estimation of the Quantity of Water.—For the purpose of determining the quantity of water, about 2,000 grains of the soap under examination should be cut into small thin shavings. These 2,000 grains should not be taken from the outside only, which is always drier, but should be cut off from the whole mass, externally and internally, so that they may represent a fair average. These shavings should be well mixed together, and 100 grains thereof being accurately weighed, should then be placed in an oven, at a temperature not exceeding 212°, until they no longer diminish in weight. The loss indicates the proportion of water. The loss of water in mottled soap should not be more than from 30 to 35 per cent., in white or yellow soap more than 45 to 50 per cent.

If the soap contain clay, chalk, silica, dextrine, fecula, pumice-stone, ochre, plaster, salt, gelatine, &c., &c., dissolve 100 grains of the suspected soap in alcohol with the help of a gentle heat; the alcohol will dissolve the soap, and leave all these impurities in an insoluble state. Good mottled soap should not leave more than 1 per cent. of insoluble matter, and white or yellow soap less still. All soap to which earthy or siliceous matter has been added is opaque instead of being transparent on the edges, as is the case with all genuine fitted soap. The drier the soap the more transparent it is.

Bone-soap, or glue-soap, is recognized by its dark colour, its want of transparency on the edges, and a disagreeable odour of glue; that made with the fat of the intestines of animals has a disgusting odour of *fæces*.

When uncombined silica has been added to soap, its presence may be readily detected by dissolving the suspected soap in alcohol, when the silica will be left in an insoluble state; but if the silica is in the state of silicate of sodium or of potassium, it is necessary to proceed as follows:—A given weight of the suspected soap should be first dissolved in a suitable quantity of boiling water, and decomposed by the gradual addition of moderately dilute hydrochloric acid. The fatty acids, which separate, being removed, the acid liquor should be evaporated to dryness; the dry mass being treated with boiling water, will leave an insoluble residuum, and may be identified as silica by its grittiness, which is recognized by rubbing it in the capsule with a glass rod. This residuum of silica is then collected on a filter, washed, dried, ignited, and weighed.

The proportion of alkali (potash or soda) contained in soap may be easily determined by an alkalimetrical assay, as follows:—Take 100 grains of the soap under examination, and dissolve them in about 2,000 grains of boiling water; should any insoluble matter be left, decant carefully the supernatant solution, and test it with dilute sulphuric acid of the proper strength, exactly as described in the article on *Alkalimetry.*

The proportion of alkali contained in soap may also be ascertained by incinerating a given weight of the soap in an iron or platinum spoon, capsule, or crucible, treating the residuum with water, filtering, and submitting the filtrate to an alkalimetrical assay. This method, however, cannot be resorted to when the soap contains sulphates of alkalies, because the ignition would convert such salts, or a portion thereof, into carbonates of alkali, which, saturating a portion of the test sulphuric acid, would give an incorrect result.

The proportion of oil or of fat in soap is ascertained, according to M. DUMAS, by adding 100 gr. of pure white wax, free from water, to the soap solution in which the proportion of alkali has been determined, and heating the whole until the wax has become perfectly liquid, and has combined with, or taken up the oil or fat which was separated by the test sulphuric acid. The whole is then allowed to cool, and the cake of wax obtained is removed and weighed; the increase above 100 grains (the original weight of the wax) indicates, of course, the quantity of grease, fat, or oil contained in the soap. The addition of wax is necessary only when the fatty matter of the soap is too liquid to concrete well on cooling. Good mottled soap ordinarily contains from 6 to 8 per cent. of soda; from 60 to 70 per cent. of fatty acids and resin; and from 30 to 34 per cent. of water.

The nature of the fat, of which a given sample of soap has been made, is more difficult to detect; but by saturating the aqueous solution of the mass under examination with tartaric acid, collecting the fatty acids which then float on the surface, and observing their point of fusion, the operator, at any rate, will be enabled to ascertain whether the soap under examination is identical with the sample from which it may have been purchased, and whether it was made from tallow or from oil, &c.

When the fatty acids which have been isolated by decomposing the soap with sulphuric or hydrochloric acid are heated in a small capsule, the odour evolved is often characteristic, or at least generally gives a clue to the nature of the fats or oils from which the soap has been made. This odour is often sufficiently perceptible at the moment when the aqueous solution of the soap is decomposed by the acid poured in.

Properly made soap should dissolve completely in pure water; if a film of fatty or oily matter is seen to float on the surface, it is a proof that all the fat is not saponified. Another test is, that the fatty or oily acid, separated by treating the soap with hydrochloric acid, should be entirely soluble in alcohol.

Soft soaps are combinations of fats or oils with potash; or rather are solutions of a potash-soap in a ley of potash, and they therefore always contain a great excess of alkali, and a more or less considerable proportion of water; they contain also a certain quantity of chlorides, of sulphates, and all the glycerine which the saponifying process has set free. The use of soft soap is chiefly used in this country for fulling, and for the scouring or cleansing of woollen stuffs; in Belgium, Holland, and Germany it is used also for washing linen, which thereby acquires a most disagreeable odour of fish-oil, the latter substance being generally employed in the manufacture of that soap. The most esteemed soft soap, however, is that made from hempseed-oil, which imparts to the soap a greenish colour; but this much-prized colour is generally artificially given to soft soap made of other oil, and which has a yellow colour, by means of a little indigo finely pulverized, and previously boiled for some time in water.

Soft soap is analyzed exactly as hard soap; good soft soap should not contain more than from 45 to 55 per cent. of water.

SOY.—Soy is a culinary preparation produced from a small bean, obtained from the *Dolichos soja*, from which a sauce is made in Japan and in China, and which is principally eaten with fish.

Genuine soy, however, is somewhat a rarity in England; most of that which is sold in bottles under that name is spurious, and consists altogether of treacle, water, salt, and a little flour, to give it greater consistence, but which latter substance is often omitted.

Genuine soy has a peculiar flavour; it should neither be too salt, nor too sweet; the colour should be brown, and when shaken in a glass it should leave on the surface a coating of a transparent, bright, yellowish-brown colour.

SPATHOSE IRON. *See* IRON ORES.

SPEISS.—Speiss is an arsenio-sulphide of nickel, which is found at the bottom of the crucibles in which smalt is prepared. Its composition is generally as follows:—

Nickel	49
Arsenic	38
Sulphur	8
Cobalt, copper, and antimony	5
	100

Nickel is sometimes extracted in this country from speiss, but in Germany speiss is always treated for nickel, for the manufacture of German silver.

The quantitative determination of the constituents of speiss may be effected in the following manner:—

The mass is first reduced into powder, and roasted as completely as possible with charcoal, in order to volatilize the arsenic; speiss being very fusible, the mass should be diligently stirred during the roasting, and if it fuses, which frequently happens, the mass should be pulverized again, and again roasted in conjunction with charcoal. After having eliminated the arsenic as completely as possible, the washed mass is dissolved in aqua-regia, and evaporated to dryness. Water is poured upon the dry mass and filtered. A stream of sulphuretted hydrogen is then passed through the solution, and the analysis proceeds exactly as we described for the analysis of Kupfer Nickel. (See the article on *Kupfer Nickel.*)

SPELTER. *See* ZINC.

SPIRITS. *See* ALCOHOL. BRANDY.

SPIRITS OF HARTSHORN. *See* AMMONIA.

SPIRITS OF SALT. *See* HYDROCHLORIC ACID.

SPIRITS OF WINE. *See* ALCOHOL.

STEEL.—'Pure iron,' writes KARSTEN (PERCY'S 'Metallurgy') 'perfectly free from carbon, is so soft that it offers but little resistance to friction, and is therefore unfitted for most of the purposes to which the ordinary metal is applied. When combined with carbon not exceeding certain limits, iron increases in tenacity, and consequently in elasticity; as also in malleability, ductility, and hardness. The last property is increased by suddenly cooling after heating, and when it is considerable, as is the case in all iron containing more than from 0·2 per cent. to 0·25 per cent. of carbon, the metal is designated steel. The more free the iron is from foreign matters, especially silicon, sulphur, and phosphorus, the larger is the amount of carbon required to induce hardening by this treatment. In the best Swedish bar-iron, as well as in bar-iron made in Germany from spathic and brown iron ore, 0·35 per cent. of carbon suffices to communicate the property of hardening in a degree so considerable that such iron is properly termed 'steely.' The passage of this iron into steel is so gradual and insensible, that it is impossible to pronounce where one ends and the other begins. When, however, the carbon reaches 0·5 per cent., and other foreign matters are present in small quantity, iron is capable of being hardened sufficiently to give sparks with flint, and may then be regarded as steel. But in the cases of iron perfectly free from foreign matters, not less than 0·65 per cent. of carbon is required to induce this properly. Iron containing from 1·0 per cent. to 1·5 per cent. is *steel*, which, after hardening, requires the maximum hardness combined with the maximum tenacity. When the carbon exceeds the highest of these limits, still greater hardness may be obtained, but only at the expense of tenacity and weldability. With 1·75 per cent. of carbon, the last property is almost completely lost. With 1·8 per cent. of carbon iron may still with great difficulty be worked and drawn out under the hammer, and although very hard, it yet retains considerable tenacity. When the carbon rises to 1·9 per cent. or more, the metal ceases to be malleable while hot; and 2 per cent. of carbon appears to be the limit between steel and cast-iron, when the metal in the softened state can no longer be drawn out without cracking and breaking to pieces under the hammer.'

Determination of the Combined Carbon in Steel (EGGERTZ) (PERCY'S 'Metallurgy').—1 gramme (= 15·432 grains) of steel, which has passed through holes of 0·2 of a line in diameter, is added in small portions to 5 grammes (= 77·16 grains) of iodine and 5 cubic centimètres (= 0·18 fluid oz.) of water, contained in a glass vessel, having a watch-glass cover, and previously cooled in ice-water. It is kept for 24 hours at a temperature of 0° C.; during the first 6 hours it should be frequently stirred with a glass rod. With these precautions, it is possible to conduct the operation without the least evolution of hydrocarbons. The insoluble residue of carbon, silica, &c., is collected on a weighed filter, and washed with hot water until it becomes white, or the filtrate is free from iron; or the residue may be washed with a solution of 2 parts of water and 1 part of hydrochloric acid heated to 70° or 80° C., and finally with water. The filter and residue are dried at 95° to 100° C. until the weight remains constant; they are afterwards ignited, and the weight of the silica, &c., is deducted. The loss by ignition represents the amount of carbon residue containing 60 per cent. of carbon; from these data the amount of carbon contained in the steel is found by calculation.

Determination of Carbon in Steel by the Colouration Test (EGGERTZ).—Sesquioxide of iron dissolved in nitric acid, if not too concentrated, yields a solution which is free from colour, or has only a feeble, greenish tint. When pig iron or steel is acted on by nitric acid, the solution is coloured by the carbon product in proportion to the amount of *combined* carbon present, and there is no action on the graphite.

A normal solution is prepared by dissolving some *cast-steel* containing a known amount of carbon, with certain precautions, in so much nitric acid of 1·2 specific gravity, that every cubic centimètre (=0·037 fluid oz.) of the solution may represent 0·001 gramme (=0·015 gr.) of carbon. This normal solution does not maintain its colour, but generally becomes paler after 24 hours. Feebly burnt sugar gives a yellow, and hard burnt sugar a brown solution; by dissolving a mixture of the two in a solution of equal parts of water and alcohol, it is possible to obtain a yellow-brown normal solution of the proper tint, which may be kept for some time in a hermetically sealed tube, pretty well protected from the influence of light. In order occasionally to control the normal solution, 0·1 grm. (=1·543 gr.) of steel containing a known weight of carbon is dissolved in 5 cubic centimètres (=0·18 fluid oz.) of nitric acid, and the solution diluted until the tint corresponds to that of the normal solution of burnt sugar.

The process is conducted as follows:—0·1 grm. (=1·543 gr.) of the finely divided steel is put into nitric acid of 1·2 specific gravity, and free from chlorine, contained in a test-tube of about 4 inches in length, and 0.4 inch diameter. The test-tube is immersed in water, and kept at the temperature of 80° C. If the temperature exceeds this, the colour of the solution decreases, and shows too small an amount of carbon. By a lower temperature the dissolving proceeds too slowly, and the colour of the liquid may be too strong.

When the evolution of the carbonic acid gas ceases, which for steel usually requires two or three hours, the test-tube is removed, and allowed to cool. The solution is then carefully decanted off from any black particles which may have been deposited during cooling into a graduated tube, a few drops of nitric acid added, and heat applied; if no evolution of gas occurs, the black particles consist of graphite, or slag; if otherwise, the test-tube is cooled, and the solution is added to that before obtained, and the whole diluted with water until the colour corresponds to that of the normal solution.

If 1 cubic centimètre of the normal solution correspond to 0·1 per cent. of carbon, and the solution in the graduated tube measures 7 cubic centimètres, then the steel operated upon contains 0·7 per cent. of carbon.

As it is usually difficult to dissolve 0·1 grm. (=1·543 gr.) of iron in less than 1·5 cubic centimètres of nitric acid, it is not possible with the before-mentioned normal solution to determine less than 0·15 per cent. of carbon. When the carbon exceeds 0·8 per cent. the solution has a greenish tint, which causes some little difficulty in comparing it with the normal solution; in such a case a poorer normal solution is made by adding 6 parts by measure of water to 3 parts of the common normal solution.

Estimation of Phosphorus in Steel (EGGERTZ, PERCY'S 'Metallurgy').—1 gramme of the powdered steel is put into a small glass containing 12 cubic centimètres (=0·43 fluid oz.) of nitric acid, sp. gr. 1·2. Heat is applied by a water-bath, and when the metal is dissolved the glass plate is removed from the mouth of the glass, and the solution is evaporated to dryness; the residue is moistened with two cubic centimètres (=0·075 fluid oz.) of nitric acid and the same quantity of hydrochloric acid, and left for about 1 hour. 4 cubic centimètres (=0·15 fluid oz.) of water are then added, and the solution filtered. The filtrate and wash-water should not measure more than from 5 to 20 cubic centimètres (=0·18 to 0.71 fluid oz.).

Not less than 2 cubic centimètres (=0·075 fluid oz.) of the prepared solution of molybdate of ammonium are then added to the iron solution for every 0·001 grm. (=0·015 gr.) of phosphorus supposed to be present in the steel, and digested for three hours, with occasional stirring, at about 40° C. If no precipitate be formed after the lapse of one hour, more solution of molybdate of ammonium is added. The yellow crystallized precipitate (if formed) is collected on a weighed filter, washed with water containing 1 per cent. of nitric acid, and dried in the water-oven till the weight remains constant. The filtrate should afterwards be tested, to see that no further precipitate is produced by the solution of molybdate of ammonium. The yellow precipitate contains 1·63 per cent. of phosphorus. If the amount of phosphorus present is large, a less quantity of iron may be taken.

The solution of molybdate of ammonium employed may be prepared by calcining finely powdered sulphide of molybdenum at a low temperature, with occasional stirring. The molybdic acid thus formed is dissolved in strong ammonia, the insoluble residue separated by filtration, the filtrate evaporated to dryness, exposed to a red-heat, and stirred until the dark blue colour becomes yellow, or nearly white, when cold; it usually contains a little *B-phosphoric acid*, and must be heated with nitric acid over a water-bath for three or four days, in order to obtain *C-phosphoric acid*, and afterwards evaporated to dryness. This molybdic acid is digested in a closed bottle with ammonia of 0·95 sp. gr. at 16° C. Four parts by weight of ammonia are added for 1 part of molybdic acid, the solution filtered and suddenly added to 15 parts of nitric acid of 1·2 sp. gr. at 16° C. The solution is commonly of a yellow colour; a small quantity of a yellow precipitate is soon formed, which contains *C-phosporic acid*, and the solution is colourless. One cubic centimètre (=0·07 fluid oz.) of the solution contains 0·06 grm. (0·925 gr.) of molybdic acid. Heated during 6 hours at 40° C., no white precipitate of molybdic acid is formed; but this occurs quickly when it is exposed to a greater heat, unless more nitric acid be added.

STICK LAC. *See* SHELL LAC.

SUBACETATE OF COPPER. *See* COPPER.

SUBCHLORIDE OF MERCURY. *See* MERCURY.

SUCCIN. *See* AMBER.

SUCCINATE OF AMMONIUM.—Succinate of ammonium is a salt which is in white crystals, unalterable in the air. The price of this substance being high, it is occasionally adulterated with *tartaric acid*; or, according to BERZELIUS, it is sometimes altogether imitated by a mixture of tartaric acid and of rectified oil of amber. This fraud is easily detected by dissolving a portion of the salt in question in water, and then adding to its solution, first, a drop of a persalt of iron, and then caustic ammonia. If the liquor contains tartaric acid, the ammonia will fail in producing a reddish brown precipitate of peroxide of iron. The adulteration may also be detected by gently igniting a portion of the salt; pure succinate of ammonium volatilizes, and leaves only a trifling residuum of charcoal, whilst tartaric acid intumesces and leaves a bulky, porous charcoal, and emits during ignition the characteristic odour of burnt bread.

SUCCINIC ACID.—Succinic acid is usually extracted from amber by subjecting the latter substance to dry distillation; but it may also be obtained by concentrating the mother-water resulting from the action of nitric acid upon wax, or upon stearic acid.

Pure succinic acid is in white, nacreous spangles, soluble in water, especially in hot water, and the solution deposits crystals in cooling; it is less soluble in alcohol, and scarcely soluble at all in ether.

Succinic acid is often adulterated with *tartaric acid, bisulphate* or *binoxalate of potassium*, and with *sal ammoniac.*

The presence of *tartaric acid* is detected by igniting a portion of the acid; if tartaric acid is present, a carbonaceous residue will be left, whilst pure succinic acid, on the contrary, evaporates completely when exposed to a red heat, upon a strip of platinum foil. If pure succinic acid be mixed with a solution of a persalt of iron, and an excess of aqueous ammonia be further added, a reddish brown precipitate of peroxide of iron will be produced; not so, however, if tartaric acid, or another non-volatile organic acid is present, at least in sufficient quantity, the solution of the persalts of iron not being precipitable by ammonia from solutions which contain non-volatile organic acids. The admixture of tartaric acid may also be detected in succinic acid by dissolving a portion of the sample in water, saturating the acid with ammonia, and then testing with a solution of chloride of calcium, which will then produce an abundant white precipitate of tartrate of calcium; whilst, if the succinic acid is pure, no precipitate will be produced. If oxalic acid or a soluble oxalate is present, chloride of calcium produces a precipitate also.

If the succinic acid under examination contains any bisulphate or binoxalate of potassium, a residuum will also be left after exposure to a red heat, which residuum being dissolved in water, may be identified as such by dividing the solution into two portions, and adding to one of the portions a solution of chloride of barium, which will then produce a precipitate of sulphate of barium, which may be collected on a filter, washed, ignited, and weighed. If a solution of sulphate of calcium, being added to the second portion, produces also a white precipitate, it is oxalate of calcium, which may be collected on a filter, washed, dried, and ignited. Ignition converts the oxalate of calcium so produced into carbonate of calcium, in which state it is weighed. 117 grains of sulphate of barium represent 146 grains of bisulphate of potassium (crystallized); 50 grains of carbonate of calcium represent 120 grains of binoxalate of potassium.

Whether the succinic acid under examination contains sal ammoniac or not, is ascertained by triturating a portion of the salt with potash; if sal ammoniac is present, an odour of ammonia will be evolved, especially if a little water be added whilst triturating. If the quantity of ammonia thus evolved is too small to be detected by the odour, a glass rod, moistened with pretty strong, but not fuming muriatic acid, is to be held at the surface of the mixture, when white fumes will immediately be observable.

SUGAR.—The sugar universally used in England is cane-sugar, which is extracted from the sugar-cane (*Arunda saccharifer*), which is raised in the English colonies. The manufacture of this important article is briefly as follows:—The juice of the cane is first boiled with lime in boilers, where it is converted into syrup, which, when sufficiently concentrated, is transferred to coolers, and thence into upright casks, perforated at the bottom, placed over a tank or cistern, into which the syrup, which has not crystallized, percolates, whilst the sugar remains in the casks in the state of *coarse* or *moist sugar*. From this *coarse* or *moist sugar*, white or loaf sugar is obtained by the refiner by various processes, which it is not the object of this work to detail.

Moist or coarse sugar is often adulterated with *sand*, *plaster*, *chalk*, *potato-flour*, and other feculas, but the principal sophistication is with *starch-* or *potato-sugar* (grape-sugar, glucose). The manufacture of starch- or grape-sugar has been so much improved that it is by no means easy to distinguish it from ordinary moist sugar, especially from that which comes from the East Indies. Starch-sugar is sometimes mixed with good muscovado, or coarse cane-sugar, and sold to the refiner and grocer as genuine cane-sugar. This admixture of grape or potato-sugar is not confined to moist or coarse sugar; pounded white sugar often contains considerable quantities of it, sometimes to the extent of 30 per cent.

The presence of grape-sugar in cane-sugar may, however, be detected in various ways:—

M. CHEVALLIER'S *Process.*—Take of distilled water 300 grains, sugar 150 grains, caustic potash 8 grains, and introduce the whole into a tube of suitable capacity and closed at one end, or in a small flask, and boil.

If the sugar be pure cane-sugar, no sensible change of colour will take place, or the solution will only take a green tinge; but if grape-sugar be present, the solution will assume a brown colour, more or less intense, in proportion to the quantity of grape-sugar present. M. CHEVALLIER says, that with a little experience that quantity may be approximatively determined. At any rate, it is a test of the presence of that substance, and, according to M. KUHLMAN, if the sugar contains from 2 to 3 per cent. of grape-sugar, the change of colour of the solution is quite distinct.

TROMMER'S *Process.*—A more delicate test is that originally contrived by TROMMER, by which even so small a quantity as $\frac{1}{100}$th part of grape-sugar can be detected. When a solution of sulphate of copper mixed with a solution of potash is poured into a solution of sugar, after boiling a few minutes a yellow hydrate of oxyde of copper is deposited. Dr. URE gives the following directions:—Dissolve a certain quantity of sulphate of copper—20 grains, for example—in a measured quantity of water, and add, in the cold, a solution of caustic potash thereto, until, by testing with turmeric-paper, the solution becomes faintly alkaline, which is known by the turmeric-paper becoming slightly brown. This forms the test-liquor, which, before using, should be well shaken. If a small quantity of this test-liquor be now added to the aqueous solution of the sugar under examination, and the whole boiled, the solution becomes at first green, and then olive-green, if dextrine is present; but if it contains grape-sugar, the salt of copper is immediately reduced into the state of orange oxide of copper; whilst the solution of pure cane-sugar undergoes no change, or scarcely any change. The proportion of oxide of copper produced affords, therefore, a good criterion of the purity of the sugar, and of the extent to which it is adulterated.

M. BARRESWILL'S *Process* consists in preparing a test alkaline solution of copper with tartaric acid, by means of which not only the quantity of sugar, but of each species of sugar, can be determined in any given solution. The experiment is performed somewhat like an alkalimetrical assay. A given quantity—for example, 1,000 grain-measures—of the test-liquor are poured into a glass beaker, or capsule, and heated therein to the boiling point; a known quantity of sugar being dissolved in 10,000 grains measure of water, 1,000 grain-measures, that is, $\frac{1}{10}$th part of it, is poured into an alkalimeter, and carefully dropped into the test-liquor in the capsule as long as a precipitate continues to be formed. If only a small quantity of grape-sugar be present, only a yellow colour of oxide of copper appears; but if that quantity is at all considerable, an abundant reddish precipitate of oxide of copper is produced. If no grape-sugar is present, no precipitate or cloudliness appears.

If now the operator has ascertained beforehand the strength of his test-liquor, that is to say, what quantity of sugar is necessary to reduce the copper contained in the test-liquor, he has only to read off what number of divisions of the solution of sugar in the alkalimeter has been employed to know the proportion of glucose it contained.

The strength of the test-liquor is ascertained by dissolving, for example, 100 grains of pure white sugar in about a pint of water, containing $\frac{1}{40}$th of its weight of hydrochloric acid, boiling the solution for one or two minutes, and adding as much water as may be necessary to bring it to exactly 10,000 grains-measure. The ebullition with hydrochloric acid converts the pure sugar into glucose (grape sugar).

To prepare the test-liquor in question, take 500 grains of pulverised cream of tartar, 400 grains of carbonate of sodium, dissolve in five ounces of water, and heat the whole to ebullition; add to the mixture 300 grains of crystallized sulphate of copper reduced to powder, boil, and allow the whole to cool; lastly, add 400 grains of caustic potash, dissolved in four ounces of water, add as much water as will make about one pint, and boil again. This liquor undergoes scarcely any change, provided it be kept in a black bottle, and in the dark.

Or, according to M. E. Krantz, take 30 grains of the sugar under examination, dissolve them in about one ounce of distilled water, filter, and add three grains of pure caustic potash (potasse à l'alcohol), and one and a half grain of sulphate of copper; shake the mixture well, and close the vessel containing it air-tight. I starch- or grape-sugar is present, a red precipitate will be formed after some time, and if in considerable quantity the copper will be entirely converted into suboxide within 20 hours. The solution is at the beginning blue or green; it then gradually loses its colour, and at last it becomes colourless and does not contain a trace of copper. Pure cane- or beetroot-sugar does not yield any red precipitate under the same circumstances, even after a lapse of eight days.

If the sugar under examination be a mixture of equal parts of cane- and of potato- or grape-sugar, the precipitation is complete within 20 hours. And even with 2½ per cent. of starch-sugar, a slight red precipitate is obtained after 24 hours, but the solution remains coloured after eight days have elapsed. The above tests are applied at the ordinary temperature.

Cane-sugar is sometimes adulterated with sugar of milk; this fraud is easily detected by treating the mixture with alcohol, specific gravity 0·852; the cane-sugar is dissolved, but the sugar of milk remains insoluble. Sugar of milk imparts a brick-red colour to arsenic acid.

Potato- or grape-sugar fuses at about 220° Fahr.; as it cools, it becomes at 150° Fahr. of the consistency of honey, and when cold, it has that of treacle, in which state it remains for a considerable time before it becomes solid again, and its colour remains unaltered; whilst pure cane-sugar requires a heat of 280° Fahr. to fuse, and it then immediately becomes brownish-black, or of a deep chestnut colour, because it then begins to be charred.

The specific gravity of a solution of cane-sugar containing 70 per cent. of sugar is 1·342, whilst the solution of grape-sugar of the same specific gravity contains 75½ per cent. of concrete matter, dried at 260° Fahr., and consequently freed from the 10 per cent. of water which it contains in the granular state.

Cane-sugar is about 29 times more sweet than grape-sugar.

SUGAR OF LEAD. *See* ACETATE OF LEAD.

SUGAR-PLUMS. *See* BLANC MANGE.

SULPHATE OF COPPER. *See* COPPER.

SULPHATE OF MAGNESIUM (Epsom Salts). *See* MAGNESIA.

SULPHATE OF QUININE. *See* QUININE.

SULPHATE OF ZINC. *See* ZINC.

SULPHUR (Brimstone).—Sulphur is a simple body which is met with in commerce in *amorphous masses*—it is then called *massive* or *native sulphur*; in rolls about 1 inch in diameter and 5 or 6 inches long—it is then called *stick* or *roll sulphur;* and in powder—'*flower of sulphur*' or *sublimed sulphur.*

The rough sulphur, in square or oblong blocks, or in amorphous masses, always contains variable quantities of impurities, which, however, are generally in too small proportions to prove materially objectionable for practical purposes. The principal impurities alluded to are *sand* or *earthy matter, oxide of iron, sulphide of iron, carbon, sulphate and carbonate of zinc, sulphate of calcium, sulphide of arsenic, alumina, magnesia,* &c.

Pure sulphur being entirely volatilizable by heat, the purity of the article may at once be approximately ascertained by igniting a given weight of the sample in a platinum crucible; the sulphur volatilizes, whilst the sand, earthy matter, and other fixed impurities are left behind, and may be weighed.

The purity of sulphur, however, can *only* be *approximately* judged from the weight of these impurities, because by this treatment the sulphides which are mixed with the sample are roasted, and abandon, if not all, at least a portion of their sulphur. It is therefore better, if greater accuracy is required, to boil the sulphur, previously pulverized, with 15 times its weight of spirits of turpentine, which will dissolve all the sulphur, which should be decanted whilst hot, and leave the impurities behind.

Rough sulphur contains generally from 7 to 10 per cent. of earthy matter, and sometimes considerably more; but good Sicilian sulphur should not contain more than 3 per cent. of impurities, and sometimes these do not exceed ½ per cent.

Sulphur lotum are the flowers of sulphur which have been washed in order to remove a small quantity of sulphurous acid, which is formed during the sublimation of sulphur. Washed flowers of sulphur are distinguished from those which have not been washed, because, on pouring boiling water on the latter, the filtering liquor reddens litmus-paper, and produces a white precipitate with solution of chloride of barium.

SULPHIDE OF ANTIMONY (Crude Antimony). *See* ANTIMONY.

SULPHIDE OF ARSENIC. *See* ARSENIOUS ACID.

SULPHIDE OF COPPER. *See* COPPER.

SULPHIDE OF ZINC (Blende). *See* ZINC.

SULPHIDE OF MERCURY (Vermilion). *See* VERMILION.

SULPHURIC ACID (Oil of Vitriol, Vitriolic Acid).— Sulphuric acid is a heavy, extremely corrosive, and intensely acid liquid, of an oleaginous consistence, which, when pure, is colourless and odourless. The *sulphuric acid of* NORDHAUSEN, which may be considered as a solution of anhydrous sulphuric in ordinary concentrated sulphuric acid, or as a combination of 2 equivalents of anhydrous sulphuric acid in 2 equivalents of water, has ordinarily a brown or brownish colour; but the ordinary sulphuric acid has frequently that colour also, which in both varieties is probably due to the presence of organic substances which have been charred by the acid. The sulphuric acid of NORDHAUSEN emits fumes in the air, and of course is so much the more powerful as it contains a larger proportion of anhydrous acid, which is disengaged by a gentle heat.

The monohydrated or ordinary sulphuric acid which has become brown by exposure, may be decolorized by heating it gently, the carbon of the organic substances being thus converted into carbonic acid.

Concentrated sulphuric acid absorbs rapidly the moisture of the air, and accordingly its volume augments considerably by exposure, for it may thus absorb several times its own weight of water. The specific gravity of sulphuric acid, in the most concentrated state, never exceeds 1·8485; when it has a density of 1·85, it is a sign of the presence of some impurity. The specific gravity of the most concentrated commercial acid never exceeds 1·847.

In taking the specific gravity of sulphuric acid the temperature must be carefully attended to, on account of the small specific heat of the acid, for the slightest increase of temperature immediately diminishes the density. Dr. URE observes, that if the thermometer be lifted out of the acid, the temperature may rise from 15° to 20° on account of the acid which adheres to it, and which absorbs moisture from the atmosphere; if the thermometer be then plunged into the acid again, the temperature of the whole is raised. This requires, therefore, particular care, since an increase of 10° Fahr.—that is to say from 60° to 70°—would bring the specific gravity of the acid from 1·8485 down to 1·7721, which, in fact, would be the gravity of the same acid diluted with 14 per cent. of water. (See Table, p. 363).

A more easy, and at the same time more accurate method of determining the strength or value of sulphuric acid, is by ascertatning its saturating power; and the most convenient way of doing this is, perhaps, by water of ammonia of a standard strength, as was first proposed by Dr. Ure. For this purpose a given weight of the acid should be diluted with water, and water of ammonia of specific gravity 0·992 is poured from an alkalimeter into it, until complete saturation is obtained. Every 1000 grain-measures of such ammonia contains one equivalent, or 17 grains of ammonia, and saturates therefore exactly one equivalent, or 40 grains of dry sulphuric acid, or 49 grains of monohydrated sulphuric acid.

Instead of ammonia-water, carbonate of sodium may be used as a test of the saturating power or actual value of the acid. For this purpose a known weight of dry, neutral carbonate of sodium, prepared as described in the article on *Alkalimetry*, should be dissolved in water, and the solution is then gradually added to the acid until complete saturation is obtained, exactly as in alkalimetry; that is to say, by dissolving the carbonate of sodium in such quantity, that each 1000 grain-measures contain 54 grains of carbonate of sodium, which therefore represent 40 grains of anhydrous sulphuric acid.

Let us suppose, for example, that 54 grains of dry, neutral carbonate of sodium having been dissolved in 1000 grain-measures of water, 85 alkalimetrical divisions (850 grain-measures) have been required to saturate 100 grains of the acid under examination previously diluted with water, if need be; then by a simple rule of proportion, we say, if 100 divisions (1000 grain-measures) containing 54 grains of carbonate of sodium, saturate 40 of anhydrous, or dry sulphuric acid, 85 divisions (850 grain-measures) have, therefore, saturated 34 grains of the same acid; and therefore the acid under examination contains 34 per cent. of real or anhydrous acid.

$$100 : 40 :: 85 : x = 34.$$

But let us suppose that 100 grains of the acid under examination, previously diluted with water, have required 160 divisions (1600 grain-measures) of the carbonate of sodium test-solution; then we say, if 100 divisions of the test-carbonate of sodium re-

Table of the Quantity of Oil of Vitriol and Dry Sulphuric Acid in 100 *parts of Dilute, at different Densities, by* Dr. Ure.

Liquid	Sp. Gr.	Dry	Liquid	Sp. Gr.	Dry
100	1·8485	81·54	50	1·3884	40·77
99	1·8475	80·72	49	1·3788	39·95
98	1·8460	79·90	48	1·3697	39·14
97	1·8439	79·09	47	1·3612	38·32
96	1·8410	78·28	46	1·3530	37·51
95	1·8376	77·46	45	1·3440	36·69
94	1·8336	76·65	44	1·3345	35·88
93	1·8290	75·83	43	1·3255	35·06
92	1·8233	75·02	42	1·3165	34·25
91	1·8179	74·20	41	1·3080	33·43
90	1·8115	73·39	40	1·2999	32·61
89	1·8043	72·57	39	1·2913	31·80
88	1·7962	71·75	38	1·2826	30·98
87	1·7870	70·94	37	1·2740	30·17
86	1·7774	70·12	36	1·2654	29·35
85	1·7673	69·31	35	1·2572	28·54
84	1·7570	68·49	34	1·2490	27·72
83	1·7465	67·68	33	1·2409	26·91
82	1·7360	66·86	32	1·2334	26·09
81	1·7245	66·05	31	1·2260	25.28
80	1·7120	65·23	30	1·2184	24·46
79	1·6993	64·42	29	1·2108	23·65
78	1·6870	63·60	28	1·2032	22·83
77	1·6750	62·78	27	1·1956	22·01
76	1·6630	61·97	26	1·1876	21·20
75	1·6520	61·15	25	1·1792	20·38
74	1·6415	60·34	24	1·1706	19·57
73	1·6321	59·52	23	1·1626	18·75
72	1·6204	58·71	22	1·1549	17 94
71	1·6090	57·89	21	1·1480	17·12
70	1·5975	57·08	20	1·1410	16·31
69	1·5868	56·26	19	1·1330	15·49
68	1·5760	55·45	18	1·1246	14·68
67	1·5648	54·63	17	1·1165	13·86
66	1·5503	53·82	16	1·1090	13·05
65	1·5390	53·00	15	1·1019	12·23
64	1·5280	52·18	14	1·0953	10·41
63	1·5170	51·37	13	1·0887	11·60
62	1·5066	50·55	12	1·0809	9·78
61	1·4960	49·74	11	1·0743	8·97
60	1·4860	48·92	10	1·0682	8·15
59	1·4760	48·11	9	1·0614	7·34
58	1·4660	47·29	8	1·0544	6·52
57	1·4560	46·48	7	1·0477	5·71
56	1·4460	45·66	6	1·0405	4·89
55	1·4360	44·85	5	1·0336	4·08
54	1·4265	44·03	4	1·0268	3·26
53	1·4170	43·22	3	1·0206	2·446
52	1·4073	42·40	2	1·0140	1·63
51	1·3977	41·58	1	1·0074	0·8154

present 40 grs. of dry acid, 160 divisions represent 64 per cent. of dry acid.

If the sulphuric acid under examination contain no sulphate in solution, its strength may be ascertained by means of a test-solution of chloride of barium; for this purpose 1050 grs. of chloride of barium should be dissolved in 10,000 grain-measures of pure water, and poured gradually into a given quantity of sulphuric acid until it ceases to produce a precipitate. Each 1000 grain-measures of the chloride of barium test-liquor corresponds to 117 grains of sulphate of barium, or to 40 grains of sulphuric acid. Towards the end a more dilute test-liquor may be employed.

The sulphuric acid of commerce always contains *sulphate of lead*, and occasionally *tin*, *nitric acid*, and *arsenic*. It is very often adulterated with *sulphate of potassium*, 2½ per cent. of which are sufficient to increase the gravity of the concentrated acid to 1·860. But whether sulphuric acid has been sophisticated or not may at once be detected simply by evaporating a given weight of the sample in a platinum capsule. The dry residuum should not exceed 1 per cent.

When sulphuric acid contains *sulphate of lead*, it becomes turbid by dilution with water; because sulphate of lead, though soluble in the concentrated acid, is insoluble in that which is diluted, and may be at once removed by filtering. The presence of sulphate of lead may likewise be detected by passing a stream of sulphuretted hydrogen through it, for in that case it becomes blackish or brown.

The presence of *arsenic*, or of *arsenious acid*, is detected also by a stream of sulphuretted hydrogen, which, in that case, will produce a yellow precipitate soluble in hydro-sulphuret of ammonia. According to M. Dupasquier, when sulphuric contains arsenic it may be purified by treatment with sulphide of barium, which produces sulphate of barium and sulphide of arsenic, both of which are insoluble in the acid.

The presence of *tin* is detected also by sulphuretted hydrogen, which, in that case, produces a brown precipitate.

The presence of *nitric* acid is detected by pouring into the acid, without diluting it, a solution of protosulphate of iron, which will then produce a brown or blackish-brown colour, which however disappears after some time; or, by adding a few drops of solution of indigo, and boiling the whole, in which case the blue colour will be destroyed; or, by immersing copper trimmings into it, which will produce a disengagement of ruddy fumes; or, by adding a small portion of narcotine, which will then produce an intensely red colour.

The presence of nitrous compounds in sulphuric acid is sometimes extremely objectionable; for when such an acid is employed for the purpose of dissolving indigo, or of charring madder, a considerable quantity of the colouring matter may be irretrievably destroyed and lost. Nitrous compounds can exist in sulphuric acid only when the latter has not been brought to the proper degree of concentration, though nitric acid is sometimes added for decolorizing sulphuric acid which has been tinged by organic impurities. For the purpose of eliminating the nitrous compounds which may contaminate sulphuric acid, PELOUZE recommends to heat the acid with a small quantity of sulphate of ammonium, the result being a formation of water and nitrogen.

SULPHURIC ACID OF NORDHAUSEN (Fuming Sulphuric Acid, Fuming Oil of Vitriol).—The sulphuric acid of NORDHAUSEN may be considered either as a solution of anhydrous sulphuric acid in the monohydrated, or ordinary sulphuric acid, or as a combination of two equivalents of anhydrous sulphuric acid with one equivalent of water. It is an oily liquid, ordinarily of a brown colour, of specific gravity 1·9. The brownish colour is due to the presence of organic matter which has been charred by the acid. The anhydrous sulphuric acid which the fuming acid holds in solution is very volatile, and the fuming property of the acid is due to the volatilization of the anhydrous acid which always escapes at the ordinary temperature from its solution, and which, combining with the moisture of the atmosphere, is condensed in the form of fumes. The sulphuric acid of NORDHAUSEN dissolves indigo much more readily than ordinary sulphuric acid; and, moreover, as it never contains any nitric acid, which destroys indigo, it is often employed in preference for that purpose. The sulphuric acid of NORDHAUSEN always contains sulphurous acid, earthy matter, and also selenium. The mode of testing the purity or strength of the fuming acid is the same as we have described for the ordinary acid.

SWEETMEATS. *See* BLANC MANGE.

TARTAR EMETIC. *See* ANTIMONY.

TARTARIC ACID.—Tartaric acid is not altered by exposure; it intumesces when heated, and then undergoes decomposition. It is soluble in water and alcohol, but its aqueous solution soon turns mouldy.

Tartaric acid is often contaminated by lime; when this is the case, it fails in dissolving completely in alcohol, which it would do if pure. The presence of lime can be identified by dissolving a portion of the acid in water, neutralizing with ammonia, and then adding oxalate of ammonium, which will produce a precipitate of oxalate of calcium, which, if in sufficient quantity, may be collected on a filter, washed, dried, and moderately ignited until all the carbon is burnt; the residuum is carbonate of calcium, which may then be weighed. 50 grains of carbonate of calcium represent 28 of lime, or each grain of carbonate of calcium contains 0·56292 grain of lime.

As tartaric acid is prepared by decomposing the bitartrate of potassium by carbonate of calcium, so as to obtain a tartrate of calcium, which is subsequently decomposed by sulphuric acid, the tartaric acid of commerce generally, or at least very often, retains a small quantity of sulphuric acid, the presence of which is detected by dissolving a portion of the tartaric acid under examination in water, and pouring into the solution a few drops of chloride of barium, which will produce a white precipitate of sulphate of barium, if sulphuric acid be present, in which case chloride of barium should be added as long as it produces a precipitate, which may then be collected on a filter, washed, dried, and weighed. 117 grains of sulphate of barium represent 40 grains of sulphuric acid, or each grain of sulphate of barium obtained is equivalent to 0·34372 grain of sulphuric acid.

Tartaric acid is often adulterated with bitartrate of potassium (cream of tartar); this fraud is easily detected by the residuum of carbonate of potassium which is left after ignition in a platinum crucible.

TARTRATE OF ANTIMONY AND POTASH (Tartar Emetic). *See* ANTIMONY.

TEA.—The following article on the adulterations of this important beverage, from the *Times* of January 19, 1874, is well worth preserving:—'The time has gone by in which tea could be treated and talked of as one of the luxuries of highly civilized existence. Two centuries ago it was a costly curiosity, sold in small parcels at from forty to eighty times the price it fetches at the present day. In "ANNE's Augustan age" it was an aristocratic beverage, sipped by wits and poets, by great statesmen and court beauties, around fashionable tables, out of rare porcelain. It was long before it conquered the prejudices and won over the tastes of the mass of the English people; but its victory, if slow, was sure and steady. Tea worked its way down through all the grades of society, in spite of the clamorous contempt of Squire WESTERN, the vigorous denunciations of COBBETT, the instincts of national Conservatism, and the sturdy rivalry of beer. It may be broadly affirmed that there is now no class of the population that cannot be properly described as tea-drinking. It merits eulogy as an universal comforter far better than its ally, sugar, on which Mr. LOWE bestowed not long ago such extravagant praise. It is the constant and indispensable drink of women of every rank, and is scarcely less appreciated by the stronger sex. This unexampled popularity of a foreign luxury has had economical results comparable for magnitude with the social changes it has wrought. Nor are there any signs of slackening in this development. In 1866 the import of tea into this country had reached what was then considered the amazing figure of 121,000,000 lb., the estimated value being 10,000,000*l.*; but the average importation in the three years 1868–70 had risen to 145,000,000 lb., and in 1872 the quantity of tea actually sent from China alone to the ports of the United Kingdom—not including the Assam and other Indian growths or the fancy teas of foreign countries—was not less than 152,283,847 lb.

'This immense consumption makes the purity and wholesomeness of the leaf a matter of the first consequence to the people of these kingdoms. In spite of the warnings of some fanatical physiologists, we have settled down in the comfortable assurance that tea, if unadulterated, is a beneficial as well as a pleasant element in our diet. But we have only too good reasons for calling in question the genuineness and innocence of a great part of the supply commonly retailed in England. Since the Adulteration Act has come into operation, several large seizures of various mixtures pretending to be tea, and the labours of competent analysts, have brought to light the existence of adventitious elements, many of them injurious to health, most of them disgusting, and all of them intended to defraud the ignorant or careless purchaser. The sale of such spurious products comes within the scope of the Adulteration Act, whether we regard that measure as designed for the protection of the public health or for the repression of commercial dishonesty. But it is obvious that the iniquitous traffic can only be kept in bounds by the imposition of frequent and severe penalties upon the offenders; and here we are met by an objection which, appealing to our sense of justice and fair play, compels us to pause. The retail grocers, who are of course the persons on whom the law lays its grasp when the sale of adulterated tea is detected, protest that they are made responsible for fraudulent practices to which the article was subjected before it came into their hands, the results of which they profess themselves incapable of detecting, and for which they disclaim any responsibility. The wholesale dealers put forward in substance the same plea. They allege that the spurious tea which is complained of, and which has been the subject of recent prosecutions, is in fact adulterated in China. There seems to be no doubt that this allegation is founded on fact. Chests of tea have been taken out of bond at the Customhouse by the Commissioners of Sewers of the City of London and condemned by a magistrate as spurious. It is only natural that the small traders should cry out that the new law punishes the innocent, while it fails to reach the guilty. Several influential Chambers of Commerce and Traders' Associations have called upon the Government to interfere by stopping the importation of all adulterated tea. This, at first sight, appears but reasonable. All the tea that is imported into this country passes, for duty-levying purposes, through the hands of the Government, and as the Government draws a large revenue from all that nominally enters our ports as tea, it is argued that the genuineness of the article on which the duty is levied should in some sense be guaranteed. The Government does not pretend to impose a Customs duty on red earth, black-lead, Prussian blue, the sweepings of floors, or the other spurious ingredients in "Lie Tea," as the Chinese call it. It is tea, and tea only, that is taxed; and the dealer contends that he has a right to be assured that the article on which he pays duty is that which it professes to be.

'An interesting correspondence which was communicated last week by the Home Office to the Vestry of Marylebone shows, however, that there is another aspect of the matter which cannot be left out of consideration. The Vestry, like many other bodies of the same class, had memorialised the Board of Trade, suggesting the propriety of taking measures for preventing the importation of adulterated food. In reply, the Home Office forwards two Reports from the Commissioners of Customs to the Treasury on the subject—the one sent in something more than two years ago, and the other about three weeks since. The tone of these Reports is strongly adverse to the assumption of any such responsibility by the Government as had been demanded by the aggrieved retailers. Sir THOMAS FREMANTLE and his colleagues expressed a very strong opinion that the existing staff of the Customs was neither adequate in point of numbers nor competent in point of knowledge to make such an examination of imported tea and similar articles as would with a certainty detect and exclude spurious products. This cannot be denied; but it is urged, on the other hand, that the staff may be increased and supplemented by a body of professional analysts; and, if the duty of the Government to guarantee the purity of imported articles be conceded, the expense will not be allowed to stand in the way. A more serious objection is that the necessary interference with the trade consequent on the establishment of any system of inspection in bond would deal a blow at British commerce by diverting from our ports the large quantity of tea, amounting on the average to more than 30,000,000 lbs. per annum, which is intended to be re-exported, and which, if delayed or exposed to the risk of confiscation, would be certainly warehoused by preference in foreign countries. We confess we do not think much of the difficulty of deciding what is and what is not adulterated tea; a few simple rules could be easily drawn up for the guidance of inspectors or analysts, which would protect "gunpowder," green teas, or "orange-scented Pekoe" against the penalties which would rightly attach to "Lie Tea." In fact, it appears to us that the commercial argument against inspection is the only one which deserves consideration. The Commissioners of Customs, in their second Report, evidently feel that the extensive powers for the suppression of adulteration now intrusted to the Local Government Board relieve them from a very onerous responsibility; and, doubtless, if the inspection of imported teas and similar articles of food should be made compulsory, it will be most effectively conducted by officers trained in the art of analysis, and subject to the rule of Mr. STANFELD's Department. We find little difficulty in agreeing with the Marylebone Vestry in the suggestion that "the Government might frame regulations which would protect the public to a very great extent, and prevent in a great measure the delivery from the Customs of adulterated tea and other produce." Only, when such regulations are being considered, their effect on the import trade must be taken into account. In the meantime we may hint that the retail dealers, however innocent of the offences for which they have been prosecuted and punished, may easily clear their characters by declining to deal with wholesale tea-merchants who will not guarantee the purity of the article they supply. The wholesale merchants have both in China and at home abundant opportunities of ascertaining whether the produce they sell is genuine or not. If they sell adulterated produce, they do so knowingly, or with that crass negligence which the law considers equally culpable with wilful wrong. The public, too, may protect themselves by insisting, wherever it is possible, on a guarantee, and by exacting without flinching the penalties that have been enacted for the repression of this wicked sort of dishonesty.'

Adulteration of Tea.—Mr. ALFRED H. ALLEN (who has contributed some valuable articles on 'Chemistry applied to the Detection of Adulterations' to the 'Chemical News') arranges the adulteration of tea under four heads:—1. Mineral additions used for increasing weight or bulk; 2. Organic additions, used for increasing weight or bulk; 3. Adulterations used for imparting fictitious strength; 4. Facings, or colouring materials.

Mr. ALLEN gives the following scheme for the detection of these adulterations (see 'Chem. News,' Nos. 751 *et seq.*):—

1. *Mineral Adulterations used for Increasing Weight or Bulk.*—Magnetic matter is best detected by pounding a known weight of the tea (say 16 grammes), and placing it on a sheet of glazed paper. A magnet is applied to the under side of the paper, and moved laterally with its poles in contact with the paper; any magnetic matter is thus readily drawn out, and separated from the tea. The use of the magnet should be continued till nothing more follows it. The magnetic matter is next boiled with water for a few minutes, to separate adherent organic particles, and water is then decanted. The residue is then weighed, and examined under the microscope as an *opaque* object. If it consist of magnetic oxide or titanate of iron, a crystalline facet will probably be apparent, the bulk of the object having a jet-black colour. Occasionally, though very rarely, *metallic* iron is present. This is distinguished from the minerals by the action of moderately concentrated nitric acid (sp. gr. 1·2), which dissolves it with the production of red fumes, but does not affect the native compounds. Metallic iron is also distinguished by its power of precipitating metallic copper when warmed with an acidulated solution of sulphate of copper. The weighing of the matter actually extracted by a magnet is far more satisfactory than the estimation of the iron existing in the tea. Tea naturally contains a small portion of iron as *phosphate*, but it only amounts to about 3 per cent. of the weight of the ash (calculated as iron), or about 0·16 per cent. of the whole tea. Of course this is not affected by the magnet, the use of which has the additional advantage of extracting the extraneous iron in the state in which it naturally exists.

Caper teas are very frequently adulterated with magnetic matter, sometimes to the extent of 7 or 8 per cent. Many tea-dealers habitually employ the magnet, the use of which is well known to the trade.

Siliceous matter is readily detected and estimated. Commence by igniting two or three grammes of the tea in a platinum dish till all organic matter is consumed, and then weighing the ash. The percentage of this at once indicates the presence or absence of extraneous siliceous matter, provided that no magnetic matter be present. The ash of genuine tea varies from 5·24 to 6·00 per cent. Owing to the presence of *steatite* in the facings of some green teas (especially gunpowder), the ash of these sometimes reaches nearly 8 per cent.

For the estimation of the amount of extraneous silica, the ash should be well boiled with water and the liquid filtered (the proportion of *soluble* ash being a valuable criterion of the presence of *exhausted* leaves). The residue is washed off the filter, or the paper ignited and boiled with concentrated hydrochloric acid. The extraneous silica, consisting of quartzose particles and insoluble silicates, is left undissolved, and after collection on a filter, washing, and ignition, it may be weighed. 'Caper tea' is the kind most frequently adulterated with siliceous matter, the amount added sometimes reaching 15 or 20 per cent. Frequently the silica exists in the form of quartz-fragments of very sensible size. Tea-dealers are well aware of the existence of this adulteration, and of the class of teas most subject to it; and they know that if present they will see the sand, &c. at the bottom of the vessel in which the tea is infused.

If desired, the iron can be estimated in the hydrochloric solution by one of the volumetric methods. (See *Iron.*)

2. *Organic Adulterations used for increasing Weight and Bulk.*—These are—exhausted tea-leaves, and leaves other than those of the tea plant. The chemical methods for the detection of these adulterants are much the same; but in the latter case we have also the botanical characters of the leaf to rely on, and these are sufficiently definite to enable us to form an opinion quite independently of the analytical results.

Exhausted tea-leaves are leaves which have been previously infused in water and then redried, with or without the addition of gum or starch.

It is evident that the effect of infusing tea-leaves in water is to extract the greater part of the soluble constituents of the tea, and that redried leaves will have a composition widely different from that of the original tea.

The two principal constituents extracted from tea by hot water are *tannin* and *gum*; more or less colouring matter, soluble salts, *theine*, &c., being also dissolved.

Tannin.—Of the soluble constituents, tannin is by far the most important and constant; but unfortunately, until recently, the methods of estimating its amount were very unsatifactory, the whole of the soluble extract, after allowing for the gum, having sometimes been called tannin.

Black tea differs from green tea in the method of its manufacture, the leaves being allowed to undergo a kind of fermentation when black tea is to be produced. During this fermentation a portion of the tannin becomes altered, with the production of dark-coloured insoluble matter, so that black tea is found to contain a higher percentage of insoluble matter, and a lower percentage of tannin, than green tea—the sum of the two constituents being moderately constant. By the process of fermentation the remaining tannin undergoes a curious change, for the tincture of green tea precipitates perchloride of iron *bluish-black*, while tincture of black tea gives a green colour with iron, just as catechu does. If excess of ammonia be added to either coloured test, a soluble oxidation product is formed of a deep blue colour.

Estimation of Tannin.—After reviewing the different methods that have been proposed, Mr. ALLEN gives the following process:—5 grammes of acetate of lead are dissolved in water and diluted to 1 litre, and the solution filtered after standing. The indicator is made by dissolving 5 milligrammes of pure *ferricyanide of potassium* in 5 c.c. of water, and adding an equal bulk of strong solution of ammonia. One drop of this test will detect 0·001 milligramme of tannin, or 1 milligramme dissolved in 100 c.c. of water.

The precipitating power of the lead solution is ascertained by diluting 10 c.c. of it to about 100 c.c. with boiling water, and adding to it from a burette a solution of 0·1 grm. of pure *tannin* in 100 c.c. of water. After adding 10 c.c. of the latter solution, about 1 c.c. of the liquid is withdrawn with a pipette and passed through a small filter, the drops being allowed to fall on to spots of the indicatory solution previously placed on a porcelain slab. If no pink colouration is observed, another small addition of the tannin solution is made, a small portion of the liquid filtered and added to the indicator as before, the process being repeated till a pink colour is observed. The greatest delicacy is obtained when the drops of liquid from the funnel are allowed to fall directly on to the spots of the indicator instead of observing the point of junction of the liquids.

The reaction being complete, a second estimation is made; and in this case almost the full volume of tannin solution can be added at once. It is necessary to use the purest tannin for the purpose, as a serious error may otherwise occur, some samples of commercial tannin having little more than half the precipitating power of the best.

Exactly the same process is employed for estimating the tannin in tea. The solution is prepared by boiling 2 grammes of the finely-powdered sample with about 80 c.c. of water for half an hour. The decoction is strained through fine muslin, the particles of leaf returned to the flask, and the boiling resumed for an hour with the same quantity of water. The process is repeated till no more colouring matter is extracted. The whole of the solution is set aside, to allow any particles that may have passed through the muslin to subside, when the liquid is decanted from the sediment, the last portions passed through a filter, and the whole decoction made up to 250 c.c. This diluted solution is ready for use in the burette, the remainder of the process only occupying a few minutes.

The volume of tannin, or tea solution—it is necessary to add to 100 c.c. of pure water in order that a drop may give the pink reaction with the ferricyanide—is subtracted from the total amount run from the burette. If the solutions are made of the strength here described, 10 c.c. of the lead solution will precipitate about 10 milligrammes of pure gallo-tannic acid, and therefore the volume of tea solution added contains 0·01 grm. of tannin. If all the weights and volumes above mentioned are observed, 125 divided by the number of c.c. of tea solution used will give the percentage of tannin, &c. in the sample.

Even after infusion tea-leaves still contain a sensible quantity of tannin, which varies from 1 to 4 per cent. according to the extent of the previous treatment. The usual amount is about 3 per cent. Taking the tannin in fresh teas at 10 per cent., and in exhausted leaves at 2 per cent., the extent to which a sample is adulterated would be found approximately by the following equation, in which E is the percentage of exhausted leaves, and T the percentage of tannin found:—

$$\text{E} = \frac{(10 - \text{T})\ 100}{8}.$$

Insoluble Matter.—When tea in its commercial condition is boiled repeatedly in fresh quantities of water till the liquid no longer becomes coloured, the residual leaves, when thoroughly dried, weigh about 50 per cent. of the original tea, if green, and about 60 per cent. if black. A large number of analyses have shown that this proportion of insoluble matter is very constant, even in teas of very different qualities; but in *broken* teas the insoluble matter is less than in unbroken, and the percentage more constant: therefore, in estimating the amount of insoluble matter in tea, it should be always done with *pounded* tea, most conveniently by drying the residue left after filtration of the tannin solution at about 100° till the weight is constant. When the process is repeated on the same tea, the results agree extremely closely with the previous estimation, rarely showing a difference of 0·5 per cent.

The estimation of insoluble matter is of importance, as a means of forming an opinion as to the presence or absence of exhausted leaves. The percentage of insoluble matter contained in *pounded previously infused* black tea-leaves varies between 72 and 75 per cent.

Gum.—This is determined by evaporating the aqueous decoction of the tea almost to an extract, treating the residue with methylated spirit, and filtering and washing with spirit. The gum is rinsed off the filter with hot water, the solution evaporated at a steam heat, and the residue weighed, ignited, and weighed again. The loss represents the gum. If the ignition is omitted, the results are too high, owing to the presence of mineral matter.

Soluble Ash.—This is determined by evaporating the aqueous solution of the ash and gently igniting the residue, which must be cooled under a desiccator. It is scarcely ever below 3·00 per cent., while *exhausted* leaves do not yield more than 0·52 per cent. The percentage of ash soluble in water is therefore a valuable independent indication of the presence of exhausted and foreign leaves.

3. *Adulterants used for imparting a Fictitious Strength.*—These are—extraneous tannin matters, such as catechu, lie-tea, soluble salts of iron, and possibly alkaline carbonates.

Extraneous tannin matters, when used in excess, will be indicated by an abnormally high percentage of tannin. Strong infusions of genuine teas, with the exception of some kinds from India, are quite clear, and do not become muddy on cooling. Tea adulterated with catechu gives an infusion which quickly becomes turbid on cooling. Under the microscope, catechu may often be recognised by its structure, and by the presence of acicular crystals. By the following chemical tests, which Mr. ALLEN considers to be tolerably reliable, the presence of catechu may be detected:—1 gramme of the pure, and the same quantity of the suspected tea, are infused in 100 c.c. of water, strained away from the leaves, and precipitated while boiling with a slight excess of neutral acetate of lead. The filtered solutions exhibit the following characteristic differences:—About 20 c.c. of the solution of pure tea, when treated with a few drops of nitrate of silver (avoiding excess), and cautiously heated, give but a very slight greyish cloudiness or precipitate of reduced silver; but the same tea, containing 2 per cent. of catechu (purposely added), gives a copious brownish precipitate, the liquid acquiring a distinctly yellowish tinge. When the proportion of catechu is somewhat larger, the filtrate from the lead precipitate gives a bright green colour on adding one drop of dilute chloride of iron ; while the solution of pure tea gives only a slight reddish colour, due to the presence of acetate. On allowing this liquid to stand, the adulterated tea gives a precipitate of a greyish or olive-green colour, the pure tea solution undergoing no change.

Lie-tea consists of the dust of tea or other leaves mixed with clay, sand, iron-ore, &c., and made into irregular masses by means of gum or starch ; it is probably composed of the general sweepings of the manufactories, and if so its nature will vary according to circumstances. When put into hot water, it disintegrates and falls to powder, in consequence of the solution of the gum or starch used for procuring the adhesion of the other materials. The iodine test for starch may be applied to the liquid, after acidifying with sulphuric acid and decolorizing with permanganate. The ash of lie-tea is often as high as 30 or 40 per cent.

Caper-tea is the name given to tea which has been made up into little glossy masses by the aid of gum or starch ; it is often glazed with graphite. That from the Canton district is invariably adulterated with sandy and magnetic matter, and often with extraneous astringents and foreign leaves. The insoluble matter in caper-tea is usually considerably less than in genuine tea : the gum often amounts to 15 or 20 per cent.

Soluble iron salts are sometimes added to tea, to give an appearance of strength by the formation of a dark-coloured tannate of iron. They may be detected by shaking the powdered leaves with cold dilute acetic acid, decanting or filtering, and testing the liquid for iron by ferrocyanide of potassium.

Facings and Colouring Materials.—Sometimes colouring matters have been used extensively for transforming black tea of low quality into superior green. Except in cases of this kind, where there is a direct fraud on the purchaser by giving the tea a fictitious appearance of value, it seems doubtful how far the facing of tea can be considered an adulteration, as it does not add appreciably to the weight of the article, and is not injurious to health.

If a portion of the tea be observed under the microscope as an opaque object, the nature of the materials used in the facing may often be recognised at once. When a faced tea is treated with warm water, the colouring matters become detached, and the small portions rising to the surface may be floated on to a glass slide, and at once examined under a microscope, while the bulk of the facing is obtained as a sediment when the strained liquid is allowed to stand. This deposit has often a distinct greenish colour, from the presence of Prussian blue or indigo. The latter of these is best recognised by the microscope; but the mineral pigment is detached by warming the tea with caustic alkali, filtering, strongly acidifying the filtrate with hydrochloric acid, filtering again if necessary, and testing the clear liquid for ferricyanide with perchloride of iron. On treating the sediment with alkali it is sure to turn brown, but this must not be taken as a proof of the presence of Prussian blue. The residue left after the treatment with caustic alkali should be treated with hydrochloric acid, and the insoluble portion washed, ignited, and fused with alkaline carbonate. In the product, silica is separated by solution in hydrochloric acid, evaporation to dryness, and re-solution in weak acid, the filtrate precipitated by ammonia and oxalate of ammonium, and the liquid filtered from this precipitate tested for magnesium by phosphate of sodium. Its detection here proves the presence of *steatite* or other *magnesian silicate*, the use of which gives the tea a peculiar smooth appearance and slippery feel. *Arsenite of copper*, *chrome yellow*, and *Dutch pink*, are also said to have been used as facings, and *sulphate of calcium* is often employed.

4. *Moisture.*—The moisture of tea in the commercial condition is generally about 6 or 8 per cent. of the weight. The lowest recorded percentage is 4·94, and the highest about 10.

5. *Theine.*—The very variable proportion of this substance present in tea prevents the estimation from being of much value for the detection of adulteration; indeed, a good process for the estimation of *theine* is still a desideratum, and Mr. ALLEN proposes the following as a method for *extracting* it merely:—

The tea is finely powdered and mixed into a paste with slaked lime and water, and allowed to rest for some hours, with occasional stirring. The mixture is next dried at a steam heat, and repeatedly treated with boiling benzol, in an apparatus allowing of the condensation of the vapour until the more colouring matter is extracted.

The liquid is filtered, and the benzol distilled off. The residue consisting of impure *theine* is boiled with water, and the solution filtered while hot. On evaporation of the aqueous solution, the *theine* is deposited in long silky crystals often grouped into tufts.

This method is, however, valueless for the *determination* of the *amount* of theine in tea, because some of it is decomposed by the lime.

Certain kinds of tea are especially liable to particular adulterations, and therefore the examinations necessary must depend on the nature of the sample. Adulterations by siliceous and magnetic matter is almost confined to *caper*, *lie*, and *gunpowder*-teas, and mixtures containing them. Extraneous astringents are often present in the above classes, and occasionally, also, in ordinary black tea. Exhausted leaves are remade into caper and gunpowder, and are also mixed with ordinary tea. Foreign leaves are met with in teas of all classes. Black tea is sometimes painted and sold as gunpowder-tea.

The highest percentage of *theine* in gunpowder-tea as yet recorded is 6·21, the lowest 1·9, but the common descriptions of tea often contain as much theine as the finest.

The highest percentage of tannin found by ALLEN in mixed hyson and gunpowder was 19·2, the lowest by BELL in very fine gunpowder, 10·22.

The highest percentage of tannin found by ALLEN in black tea (very strong Oolong congou) was 15·2; the lowest by BELL (finest souchong) 9·5.

The average of 5 determinations of insoluble matter in black tea gave BELL a percentage of 58·77. The highest percentage on pounded tea (Moning congou) was, according to ALLEN's experiments, 53·6, and the average of 13 experiments 490.

The following percentages of ash have been obtained:—Average of 7 experiments (WANKLYN), 5·75; of 9 experiments (WILSON), 5·66; of 24 experiments (WIGNER), 5·66; of 20 experiments (ALLEN), 5·75.

TERRA JAPONICA. *See* CATECHU.

TIN.—Metallic tin is solid, malleable, of a white colour very much resembling that of silver, but with a slight tint of yellow, and is not sensibly altered by exposure to the air; it emits a peculiar crackling noise when bent, the intensity of which, however, is considerably diminished when alloyed with other metals. It exhales a peculiar metallic odour when rubbed, and melts at 442° Fahr.; its specific gravity varies from 7·29 to 7·6, and is not augmented by hammering. The best kind of tin is known in commerce under the name of *grain-tin*; that called *block-tin* is less pure. Tin is not volatilizable by heat. It is insoluble in nitric acid, by which, however, it is converted into peroxide of tin, but is readily dissolved by hydrochloric acid.

Commercial tin is often contaminated by several metals with which it is accidentally or purposely mixed, but which render it unfit for various purposes; hence the importance of ascertaining whether it is pure or impure. According to VAUQUELIN, when tin has a bluish or greyish tinge, it is a sign of the presence of *copper*, *lead*, *iron*, or *antimony*.

The best way of ascertaining the purity of tin is by melting a quantity in an iron ladle, and when melted pouring it carefully either into another large iron ladle, or in a porcelain capsule, tilting it gently on one side before the metal has cooled, in order to obtain a bright and perfectly smooth surface, free from oxide or impurity. If the convex surface of the metal is of a perfectly white colour, free from spots or wrinkles, it is a sign of purity; but in the contrary case, or if it has a bluish, or greyish, or leaden tinge, presenting a sort of *moiré métallique,* then the above metals may be present.

If, however, by comparing the melted piece with another sample of tin known to be pure, it is harder and whiter than it should be, the presence of arsenic is probable. Arsenic considerably hardens tin.

Pure tin when bent produces one single and strong crackling noise; but if impure, the crackling noise is feeble, and gives the idea of a tearing noise, more prolonged than when the metal is pure. When this takes place, the presence of lead or of copper may be inferred.

If a piece of tin, being bent several times backward and forwards, first becomes elongated before it breaks, and if the fracture is in points, and has a dead-white colour and looks soft, the tin is pure. When *lead, copper,* or *iron* are present, the tin is more brittle, and the fracture is granular and grey.

The specific gravity of the tin is also a sign of its purity; for, as pure tin is lighter than the metals with which it may be alloyed, its specific gravity will of course be so much the greater in proportion to the quantity of the alloy.

The nature of the foreign metals by which tin is contaminated may be detected by dissolving a portion of the sample in dilute hydrochloric acid. If brown flakes (or a black powder) are deposited, they are owing to the presence of arsenic.

If a portion of the tin, being dissolved in aqua regia, and the solution filtered and diluted with water, produces a blue precipitate (Prussian blue), when tested with solution of ferrocyanuret of potassium, *iron* is present.

If the precipitate produced by that reagent is purple, *copper* and *iron* are present; in which case a bar of iron plunged in the nitric acid solution of the tin will receive a coating of copper, if that metal be present.

If a solution of sulphate of sodium produces a white precipitate, *lead* is present.

The amount of these impurities may be determined as follows:—

Take about 1,000 grains of the sample, first reduced into small bits or granulated (which is easily done by melting the tin and triturating it in a mortar whilst cooling), and dissolve them in about a pint of dilute hydrochloric acid; the addition of a few drops of dilute nitric acid from time to time accelerates the solution of the tin. If the metal contain arsenic, a residuum, insoluble in hydrochloric acid, will be left, which is arsenic almost in a pure state, and which may be recognized as such by the aliaceous odour which it evolves when thrown upon ignited coals. It is necessary to employ only a dilute acid, in order that the metal may dissolve slowly, for otherwise no arsenic would be deposited, for it would be converted into arseniuretted hydrogen, which, however, may be recognized as such by Marsh's apparatus.

The quantity of *lead*, of *copper*, or of *iron*, may be estimated by treating 100 grains of the sample with boiling nitric acid, which will dissolve these metals, and leave the tin in the state of peroxide. The best way is to evaporate the nitric acid solution with the undissolved peroxide of tin until the excess of nitric acid is mostly volatalized; water is then added, the peroxide of tin is collected on a filter, washed, ignited, and weighed; each grain of peroxide of tin thus obtained contains 0·7866 of tin. The loss, or difference, indicates of course the other metals with which the tin was alloyed.

If the operator now wishes to ascertain the respective proportion of these foreign metals, he should proceed as follows:—

The liquor which was filtered from the peroxide of tin should be treated by dilute sulphuric acid, or by a solution of sulphate of sodium; if this produce a white precipitate, it is sulphate of lead; this precipitate should be collected on a filter, washed, and then ignited in a crucible and weighed; 100 grains of sulphate of lead contain 73·6 of oxide of lead, and, consequently, 68·33 of metallic lead; or each grain of sulphate of lead contains 0·6833 of lead.

After having eliminated the lead in the state of sulphate of lead, and if only *iron* is present, it may be determined as peroxide of iron by means of caustic ammonia; but if copper be present at the same time, it is better (provided no other oxides which can be precipitated by sulphuretted hydrogen from an acid solution are present) to pass a stream of that gas slowly through the filtered acid liquor until it smells strongly of the gas. The black precipitate produced is sulphide of copper, and must be rapidly collected on a filter and washed without interruption with water containing a little sulphuretted hydrogen. After washing the precipitated sulphide of copper, it should be dried, separated from the filter as cleanly as possible, and put into a flask. The filter, which retains a little sulphide of copper, must now be burnt upon the cover of a crucible, and the ashes added to the sulphide in the flask. Nitric acid, or aqua regia, is then poured upon the whole, which is left to digest therein until the sulphur liberated has acquired a pure yellow colour. The sulphur is separated by filtering, and the copper is precipitated by pouring a solution of potash into the filtered liquor as long as a precipitate is produced. The whole is then boiled; the oxide of copper thus produced is collected on a filter, washed with hot water, ignited with the filter in a platinum crucible, and weighed as soon as cold in the crucible, which should be kept carefully covered, as otherwise the oxide of copper would absorb moisture, which would thus increase the weight. Each grain of oxide of copper contains 0·7987 of copper.

Tin may be obtained in the pure state by dissolving commercial tin in hydrochloric acid, so as to obtain a concentrated solution; and when the solution has cooled, water is to be carefully poured upon it, so that the water may form a distinct layer above the tin solution. A blade of tin is then plunged through the liquor down to the bottom, and in the course of a few hours the blade becomes covered with exceedingly fine crystals of tin. This reaction is due to the slight electric current produced by the immersion of the tin through the two layers of chloride and of water, which current is sufficient to determine the precipitation of the tin.

The quantity of arsenic which is contained in ordinary tin does not amount generally to more than $\frac{1}{600}$th part, and the tin of Malacca and Banca do not contain appreciable quantities of this poisonous metal.

Pewterers generally alloy their tin with a little antimony, in order to render the metal harder; the analysis of such an alloy may be made as described in the article on *Antimony*, to which the reader is referred.

The *native oxide of tin*, or *pyramidal tin-ore*, is the principal ore of tin; it consists of peroxide of tin mixed with small quantities of iron and of manganese; it is so dense that it is insoluble in acids, and it resembles, in that case, the artificial peroxide of tin after ignition.

In order to determine the quantity of foreign substances contained in the ore, it (the ore) should be finely pulverized, levigated, mixed with three or four times its weight of carbonate of potassium or of sodium, and fused. After fusion, the peroxide of tin may be dissolved in hydrochloric acid, and the solution being evaporated, in order to expel the excess of acid, is then diluted with a sufficient quantity of water and filtered; sulphuretted hydrogen is passed through the liquor until it smells strongly of the gas, which will precipitate the tin in the state of sulphide of tin. The precipitated sulphide of tin is then somewhat dried, put into an open platinum crucible, and gradually roasted therein, until it ceases to evolve any odour of sulphurous acid (burning sulphur); the heat may then be increased to a good red. That which remains in the crucible is peroxide of tin, which should be white; it is then weighed. A small piece of carbonate of ammonium should be placed upon the peroxide of tin in the platinum crucible, and the whole again strongly ignited. This must be repeated as long as the loss of weight is observed. The carbonate of ammonium is employed for the purpose of expelling the last traces of sulphuric acid, produced by the roasting, which the peroxide of tin might retain.

If the operator wishes to isolate the iron, and to determine its quantity, the filtered liquor should be heated until all odour of sulphuretted hydrogen has vanished; some nitric acid is then added, and the liquor is boiled, in order to peroxidize the iron, which may then be precipitated by ammonia, collected on a filter, washed, dried, ignited, and weighed. Each grain of peroxide of iron contains 0·70 grain of metallic iron.

TINKAL. *See* BORAX.

TOMBAC. *See* GERMAN SILVER.

TURNBULL'S BLUE. *See* PRUSSIAN BLUE.

TUTENAG. *See* GERMAN SILVER.

VERDIGRIS. *See* COPPER.

VERDITER. *See* COPPER.

VERMILION (Cinnabar, Sulphuret of Mercury).—1. Cinnabar and vermilion are the same substance; that is, a combination of sulphur and of mercury. Cinnabar is in lumps or amorphous masses of variable size, of a reddish-purple colour, and consisting of an agglomeration of needles, parallel to each other. The specific gravity of cinnabar is 10·218. When cinnabar is pulverized, it forms the beautiful red pigment called vermilion.

2. Vermilion is often fraudulently mixed with *red lead*, *peroxide of iron*, *brick-dust*, and with *sulphide of arsenic*.

3. The presence of *red lead*, *peroxide of iron*, and of *brick-dust*, is easily detected, because vermilion being volatilizable by heat, it is sufficient to pour a small portion of the vermilion under examination into a well-scoured iron-spoon, and to heat it; the vermilion soon evaporates, whilst the red lead, brick-dust, and peroxide of iron, not being volatile, are left behind. The dif-

ference of weight, before and after the experiment, indicates at once the amount of fraud.

4. If *sulphide of arsenic* is present, it may be detected by throwing a little of the vermilion under examination upon ignited charcoal, when the characteristic odour of garlic, indicating arsenic, becomes perceptible. The odour of garlic is developed better by mixing a little of the vermilion with carbonate of sodium, and heating the mixture before a blow-pipe upon charcoal. The presence of sulphide of arsenic may also be detected by boiling a portion of the vermilion in caustic potash and filtering, supersaturating the filtrate with nitric acid, and then passing a slow current of sulphuretted hydrogen through the solution, which will precipitate the arsenic in the state of yellow sulphide of arsenic.

5. After having ascertained the presence of arsenic, as above said, its quantity may be determined in the following manner:—Take a given weight of the vermilion in very fine powder, put it into a flask, and treat it therein with aqua regia until the sulphur, which separates, has agglomerated into yellow lumps, of a perfect yellow colour; fresh portions of aqua regia being added from time to time in order to insure complete decomposition. The solution is filtered and supersaturated with ammonia; an excess of hydrosulphuret of ammonia is then added, the flask is loosely corked up, and the whole is left to digest in a warm place for ten or twelve hours. The flask is allowed to cool, and when quite cold the insoluble sulphide of mercury may be separated by filtering. The filtrate, which contains the sulphide of arsenic, should be diluted with a large quantity of water, acidified with a little hydrochloric or acetic acid, until it is slightly acid, and the whole is left to digest at a gentle heat, until all odour of sulphuretted hydrogen has disappeared. The sulphide of arsenic which was held in solution will then have completely precipitated; it should therefore be collected on a counterpoised filter and weighed. It is necessary, however, for accurate purposes, to analyse the sulphide of arsenic thus obtained, because it is mixed with sulphur, from the decomposition of the hydrosulphuret of ammonia by the acid employed.

6. The presence of *red lead* may be identified by boiling a portion of the vermilion in acetic acid, which will dissolve the lead; and if on passing a current of sulphuretted hydrogen through a portion of the filtered solution, a black precipitate of sulphide of lead is obtained, or if, in testing another portion of the filtered solution with iodide of potassium, a yellow precipitate is obtained, it is a sign of the presence of lead.

7. In order to determine the quantity of the red lead, the

black precipitate of sulphide of lead produced in the acetic acid-solution, as above metioned, is treated with the filter by hydrochloric acid, which produces a disengagement of sulphuretted hydrogen. Nitric acid is then added, and the whole is evaporated to dryness; sulphuric acid is now poured with care on the dry mass, the excess of sulphuric acid is eliminated by heat, and the remaining sulphate of lead is weighed. 152 grains of sulphate of lead = 104 of lead, or 344 grains of red lead.

VINEGAR (Acetic Acid, Pyroligneous Acid).—Vinegar is the name given to dilute acetic acid, the strength, flavour, and composition of which varies according to the sources from which it has been produced. The best vinegar is that which is obtained from wine, by exposing it to the action of the air, at a proper temperature. In this country vinegar is made from beer, or from a *wort* prepared for the purpose; but cider, perry, and a great number of alcoholic or saccharine liquors, can be converted into vinegar. 124 parts of sugar, 80 parts of yeast, and 868 parts of water, exposed to the air for about a month, yield vinegar of a good quality. Vinegar is extensively manufactured also from the destructive distillation of wood, and is known under the name of pyroligneous acid.

Pure acetic acid is solid up to a temperature of 62·6° Fahr. At that temperature it melts into a colourless liquid of specific gravity 1·063; it has a peculiar characteristic odour, and is as corrosive as the most powerful mineral acids. Acetic acid is soluble in water in all proportions; it boils at 248° Fahr.; its vapour is inflammable, and burns with a blue flame. The density of acetic acid is augmented by diluting it with water. Acetic acid, which contains only 1 equivalent of water, has a density of 1·063; by diluting it with about 30 per cent. of water its density becomes 1·079, which is its maximum gravity; if diluted with more water, its specific gravity is the same as when it contains only 1 equivalent of water, as shown in the following Table by M. MOLLERAT:—

Specific Gravity.	Quantity of Water per cent. of Concentrated Acid.
1·0630	0·0
1·0742	10·0
1·0770	22·5
1 0791	32·5
1·0763	43·0
1·0742	55·0
1·0728	66·5
1·0558	97·5
1·0637	108·5
1·0630	112·2

This Table shows that the strength of acetic acid cannot be estimated from its specific gravity.

Vinegar is often adulterated in various ways; namely, by dilution with water, or with vinegar of inferior quality, or by an addition of pyroligneous acid or of sulphuric acid. Its pungency is often increased by maceration with acrid substances, such as chillies or cayenne-pepper, long-pepper, mustard-seed, &c.; it is also mixed sometimes with metallic salts, common salt, &c.

The only accurate method of determining the quantity of acid contained in vinegar is by ascertaining the quantity of dry carbonate of sodium which may be required to saturate it.

Professor Soubeiran says that 100 parts of vinegar of good quality (French vinegar, vinaigre d'Orléans) are saturated by 10 parts of dry carbonate of potassium.

A test-liquor for this purpose may be made by dissolving 540 grains of dry carbonate of sodium in 10,000 grain-measures of water. 1,000 grain-measures (100 alkalimetrical divisions) of such a liquor are then taken and poured gradually from an alkalimeter-tube into a given measure (1 fluid ounce for example) of the vinegar under examination, until its acid is saturated. 100 divisions (1,000 grain-measures) of such a test-liquor saturate exactly 51 grains of pure anhydrous acetic acid; 1 ounce of good vinegar should require from 58 to 60 divisions (580 to 600 grain-measures) for saturation. Before adding the test-solution of carbonate of sodium, a small quantity of tincture of litmus should be added to the vinegar in order to guide the operator, and enable him to see when the point of saturation is nearly attained. Towards the end of the experiment heat should be applied in order to expel the carbonic acid. The operator will perceive that, as the saturation proceeds, the odour of vinegar disappears, and is replaced by a peculiar soapy odour; the red colour of the vinegar, tinged with litmus at the same time, is gradually changing into blue. The experiment is, in every respect, conducted as for alkalimetry. (See *Alkalimetry.*)

When the experiment is finished the operator reads off the number of divisions employed, and if, for example, 58 divisions have been employed to saturate 1 fluid ounce of vinegar, then it contained 29·58 grains of pure anhydrous acetic acid.

The ammonia test-liquor, recommended by Dr. Ure, which admits also of very great accuracy, may be resorted to for the same purpose. The process consists, first, in pouring some neutral tincture of litmus into the vinegar to be tested, so as to impart a feeble red tinge to it, and then testing with the ammoniacal solution of sp. gr. 0·992; 1,000 grain-measures of such an ammoniacal solution, containing exactly 1 equivalent of ammonia, neutralize consequently 1 equivalent of acetic acid, that is, 51 grains of the anhydrous, or 60 of the monohydrated acid. The test-ammonia can always be easily kept at the proper strength by two hydrostatic glass beads, made, the one to float, the other to sink in the ammonia liquor of the proper gravity as above said. If, then, a portion of such a test-liquor of ammonia be added to the slightly reddened vinegar until the colour is neutralized, the number of grain-measures employed being multiplied by 51 or 60, will give a product which indicates the percentage of either real anhydrous or hydrated acid in the vinegar operated upon.

It is evident that, in the above acidimetrical process, account must be taken of any mineral acid which may have been, and is generally added to vinegar, and the presence and amount of which must, of course, be determined.

Detection of Sulphuric Acid in Vinegar.—Take a known quantity of the vinegar under examination—8 fluid ounces, for example—and evaporate it in a steam- or water-bath to about one-eighth of its bulk, allowing the capsule to cool, and add 5 to 6 times its bulk of alcohol, the whole being well stirred with a glass rod. The liquor should then be filtered in order to separate the insoluble sulphates; and solution of chloride of barium being then added to the filtered liquor, a precipitate of sulphate of barium will be produced if sulphuric acid is present. The precipitated sulphate of barium should be drenched with nitric acid, filtered, washed, dried, slightly ignited, and weighed. 117 grains of sulphate of baryta represent 40 of anhydrous sulphuric acid; or, each grain of sulphate of barium contains 0·34372 of sulphuric acid.

For less accurate purposes the operator may dispense with evaporating the vinegar, and treating it with alcohol, and may at once estimate the sulphuric acid by pouring chloride of barium in a known quantity of the vinegar until a precipitate ceases to be produced. The precipitate is then treated as above described.

Detection of Pyroligneous Acid in Vinegar.—This adulteration is very common, and may always be recognized by the empyreumatic smell and taste, which is very characteristic, but which is not otherwise detrimental.

Detection of Acrid Substances in Vinegar.—Pepper, capsicum, or chillies, mustard-seed, and other acrid substances, are sometimes added to vinegar for the purpose of simulating strength. The presence of these substances may be detected by saturating the acid with an alkali. The acidity of the vinegar being thus destroyed, the acrid taste of the substances employed will then become perceptible.

Detection of Metallic Salts in Vinegar.—The salts occasionally met with in vinegar are principally those of copper, of lead, of zinc, and are generally referable to the utensils employed in the manufacture of that acid. The presence of lead is detected by testing the vinegar with iodide of potassium, or with chromate of potassium, both of which produce a yellow precipitate. The yellow precipitate produced by the first of these reagents is soluble in hot water, and likewise in a large excess of the reagent; that produced by chromate of potassium is soluble in a solution of pure potash, and if digested with ammonia it becomes of a reddish or orange-red colour. In using this last reagent it should be applied in a dilute state. If lead is present a current of sulphuretted hydrogen will produce a black precipitate.

If *copper* is present sulphuretted hydrogen will also produce a black precipitate, but in that case a portion of the vinegar first decolorized by animal charcoal will be rendered blue by ammonia, and brown or crimson by ferrocyanide of potassium.

The presence of *zinc* may be detected by means of ferrocyanide of potassium, which will produce a precipitate. But the most characteristic way of detecting the presence of this metal consists in neutralizing the vinegar with ammonia, filtering, and testing the clear ammonical and colourless filtrate with hydrosulphuret of ammonia. If a white precipitate is produced, zinc is present. The smallest proportion—a trace—of iron is sufficient to give a grey colour to the precipitate, and if the quantity of iron present is more considerable, the precipitate is black.

Quantity of Extract resulting from the Evaporation of Genuine Vinegar made from Wine.—According to Messrs. Jules Garnier and Harel, the evaporation of 1000 grains of 12 samples of pure wine-vinegar gave:—

				Grains
No. 1.	1000 grains		=	23
2.	,,	,,	=	17
3.	,,	,,	=	22
4.	,,	,,	=	21
5.	,,	,,	=	20
6.	,,	,,	=	22
No. 7.	1000 grains		=	20
8.	,,	,,	=	18
9.	,,	,,	=	19
10.	,,	,,	=	23
11.	,,	,,	=	17
12.	,,	,,	=	24

The minimum of extract produced from pure wine-vinegar is therefore 1·70 per cent., and the maximum 2·4 per cent., the average being 2·05 per cent.

These results may, to a certain extent, serve to indicate whether the wine-vinegar under examination is genuine or spurious, since the quantity of extract obtained from spurious vinegar is always much more considerable. Wine-vinegar yields less extract than all other vinegars; and, moreover, if its extract be treated with alcohol, it will almost entirely redissolve and leave a residuum of tartar, whilst the vinegar made from glucose, or sugar of starch, leaves after evaporation a residuum which is only sparingly soluble in alcohol, and remains soft and glutinous.

Vinegar made from Beer, Cyder, or Perry.—Vinegar made from beer, cyder, or perry, may be distinguished from wine-vinegar, because they contain no tartar, and their saturating power is much inferior to that made from wine (after deducting the sulphuric or other acids which they may contain); so that whilst two parts of good wine-vinegar require 10 parts of carbonate of sodium, the same quantity of cyder-vinegar and of beer-vinegar require, the first 3·5, the second 2·5 parts of carbonate of sodium.

The density of the best white wine-vinegar is about from 1·020 to 1·025, that of beer-vinegar is 3·20, and of cyder-vinegar about 2·0.

Beer-vinegar yields by evaporation 6 per cent., and cyder-vinegar 1·5 per cent. of extract; the latter has an odour of baked apples. the former has an acid and slightly bitter flavour.

VITREOUS COPPER. *See* COPPER.

VITRIOL. *See* SULPHURIC ACID.

VITRIOL (BLUE). *See* COPPER.

VITRIOL (ROMAN). *See* COPPER.

VITRIOLIC ACID. *See* SULPHURIC ACID.

VOLATILE ALKALI. *See* AMMONIA.

WATER.—For certain technical and for analytical purposes chemically pure water is absolutely requisite, and may be obtained in that state by distillation (see *Glossary*), by which operation it is separated from the foreign substances which it may hold in solution, some of which are of a volatile nature, such as carbonic acid, oxygen, nitrogen, ammonia, nitrate and carbonate of ammonium. The others are fixed, such as salts of potassium, of sodium, calcium, magnesium, aluminum.

In order to obtain pure water, the distillation should be stopped when the salts which were held in solution begin to deposit, for if the process be continued, part of these salts might undergo decomposition and contaminate the distillate.

The characteristics of pure water are, that it must not produce any precipitate, or become turbid when tested by the following reagents :—

Lime-water	If a precipitate or turbidness be produced soluble in hydrochoric acid, carbonic acid is present.
Chloride of barium Nitrate of barium	If a precipitate or turbidness is produced, sulphates are present.
Nitrate of silver	Indicates the presence of chlorides.
Oxalate of ammonium	Do. do. of salts of calcium.
Sulphuretted hydrogen	Do. do. of various metals.
Hydrosulphuret of ammonia	Do. do. do.
Perchloride of mercury Perchloride of gold Sulphate of zinc	Do. do. of organic matter.

Pure distilled water evaporated upon a piece of platinum-foil should leave no residuum. Water distilled from rivers that run near or through populous towns—such as the water of the Thames, for example, or the Severn, the Tyne, &c., the Seine, Rhone, and Saone, &c. on the Continent—always, or generally, contain a certain quantity of carbonic acid, of ammonia, and of organic matters, which pass over with the distillate, and are subsequently found therein. The presence of these impurities, however, does not interfere with the usual analytical operations; yet it is advisable to stop when four-fifths of the water have distilled, but more especially to reject the first portions that come over.

Distilled water, however pure, is unfit to drink; having been deprived of air by ebullition, it is insipid, heavy, and indigestible. Rain-water contains all the substances which exist in the air, namely oxygen, nitrogen, carbonic acid, carbonate of ammonium, nitrate of ammonium, and sometimes (especially after storms) traces of nitric acid; it holds, moreover, in suspension, dust and other minute fixed particles which are floating in the atmosphere, and which are always found in greater abundance in the first portions of rain that fall. When therefore rain-water is received into clean vessels, taking care to throw away the first portions, it may replace distilled water in most chemical operations.

Spring- or well-water is never pure, on account of its having filtered through strata of various compositions; it contains chlorides, sulphates and carbonates of calcium, of magnesium, and sometimes of potassium and of sodium.

To be fit for use as an ordinary beverage and culinary purposes, water should be perfectly sweet, limpid, and clear; it should readily lather with soap; when evaporated to dryness, it should leave only a small residuum, and remain for a long time transparent whilst boiling; it is only when reduced to a very small bulk by evaporation, that it should begin to become turbid; and if an alcoholic solution of soap be poured into it, a small portion of the soap only should be curded. Such water is then called *soft* water.

Hard water, on the contrary, holding in solution a large proportion of certain salts, is not so well adapted for cooking and washing, because the soap is thereby converted on the surface into an insoluble margarate, stearate, and oleate of calcium, and the small quantity abraded by friction forms a curdy, insoluble precipitate.

Spring-water belongs to the latter class. Some spring-waters contain a large quantity of sulphate of calcium, and consequently afford a corresponding abundant precipitate when treated by oxalate of ammonium, which precipitate is oxalate of calcium; and by chloride of barium, which precipitates the sulphuric acid as sulphate of barium.

Water which contains sulphate of calcium can be rendered fit for domestic purposes by the addition of a quantity of carbonate of sodium sufficient to decompose the sulphate of calcium, the results being sulphate of sodium which remains in solution and carbonate of calcium which is precipitated. Many kinds of spring-water owe their hardness to the presence of a quantity of carbonate of calcium held in solution by an excess of carbonic acid; such waters may be rendered fit for domestic use by boiling, by which the excess of carbonic acid is expelled and carbonate of calcium precipitated. The same result is obtained by pouring into such water a sufficient quantity of lime-water to saturate the excess of free carbonic acid; a neutral carbonate of calcium is thus produced, whilst that which existed in the solution being at the same time reduced to neutral carbonate, is also precipitated.

River-water, when not contaminated by the discharge of the contents of sewers, is more pure than spring-water; it contains the same salts as spring-water, but in less proportion, and the quantity of carbonic acid is also less in river- than in spring-water.

Well-water is generally *harder* than spring-water, and is consequently not so well adapted for cooking or washing, unless treated as above mentioned.

If the water contains carbonate, sulphate, or some other salt of iron in solution, tincture of galls, or solution of ferrocyanide of potassium are the reagents usually employed to detect it. The first will produce in the liquid a purple-black (ink) colour or tinge; the second will produce a bluish-white colour, gradually becoming blue.

If lead be present, sulphuretted hydrogen will produce a black precipitate, or only a brownish tinge, if only a trace be present. Most metals can be detected in water by this reagent; if the water is pure, a slight milkiness only will be produced by it.

Sea-water is bitter, salted, and has a nauseous taste; it is altogether unfit for drinking. Its analysis, by several chemists, yielded the following results:—

Substances contained in one litre* of Sea Water	Atlantic Ocean				Mediterranean Sea	
	Bergman	Marcet	Lagrange and Vogel	Murray	Lagrange and Vogel	Laurent
			Litre		Litre	Litre
Carbonic acid . .	...	...	0·230	...	0·110	0·200
	Grains	Grains		Grains		
Chloride of sodium .	32·155	26·600	26·646	21·80	26·646	27·220
„ magnesium	8·771	5·154	5·853	4·86	7·203	6·140
Sulphate of magnesium	...	...	6·465	...	6·991	7·020
„ calcium .	1·039	...	0·150	...	0·150	0·150
Carbonate of calcium and of magnesium	...	...	0·200	...	0·150	0·200
Chloride of calcium .	...	1·232	...	0·78	...	...
Sulphate of sodium .	...	4·660	...	3·50	...	...
Potash	...	...	...	...	...	0·010
Iodine, probably in the state of iodide of potassium .	...	...	...	...	...	indefinite quantity
Bromine, probably in the state of bromide of magnesium .	...	...	...	...	...	do.
Total . . .	41·965	37·646	39·314	30·94	41·140	40·740

The composition of sea-water, however, is not uniform; the amount of its constituents varies according to localities. We give here the results of the analysis of the water of the English Channel by Schweitzer, and of the Mediterranean Sea by Laurens. (*See* Table on next page.)

Quantitative Analysis of Water.—Estimation of Carbonic Acid.—The water for this purpose must be collected at the spring or well by immersing in the water a large pipette of exactly known capacity; four or five stoppered bottles, each of about a pint capacity, should be charged each with one ounce of a strong solution of chloride of calcium and an ounce and a half of

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* The litre contains 51·12079 cubic inches, or 1·76377 pint.

	English Channel	Mediterranean
Water	964·74372	959·26
Chloride of sodium . .	27·05948	27·22
" potassium .	0·76552	0·01
" magnesium .	3·66658	6·14
Bromide of magnesium .	0·02929	—
Sulphate of magnesium .	2·29578	7·02
" lime. . .	1·40662	0·15
Carbonate of calcium .	0·03301	and magnesium } 0·20
	1000·00000	1000·00

ammonia, free from carbonic acid; they should then be filled with the water poured quietly in, to prevent any loss of carbonic acid from splashing; all the carbonic acid contained in the water will thus be precipitated in the form of carbonate of calcium. The precipitates in the different bottles, which should be nearly alike in quantity, are collected on a filter, dried at 212°, and weighed. They are then mixed together, and analysed by FRESENIUS' and WILLS' method; the result shows the total amount of carbonic acid in the united volumes of the several bottles of water.

Determination of the Total Amount of Solid Ingredients.—A quantity of the water (varying from 1,000 to 10,000 grains) is carefully evaporated to dryness in a platinum capsule on the water-bath, the residue is dried at various temperatures, and the weight taken when no further diminution is perceptible. If the water contain any considerable amount of earthy chlorides, a very exact result cannot in this manner be obtained regarding the amount of the solid contents, for the earthy chlorides retain a small proportion of water at 212°, while, at a higher temperature, some hydrochloric acid may be set free. The best method, therefore, is to evaporate the water with the addition of a known quantity of pure anhydrous carbonate of sodium sufficient to decompose the earthy chlorides and sulphates. This method of evaporating with carbonate of sodium is advantageous, moreover, as preventing the formation of sulphate of calcium, which is a troublesome ingredient, inasmuch as it adheres closely to the evaporating vessel, is not readily soluble in dilute hydrochloric acid, and very sparingly soluble in water.

Estimation of the Sulphuric Acid.—Ten thousand grains (more or less, according as the preliminary experiment has indicated a greater or less amount of sulphuric acid) are acidified with hydrochloric acid, and precipitated at a boiling temperature by chloride of barium; the precipitate is allowed to settle, then collected on a filter, washed, dried, ignited, weighed, and the amount of sulphuric acid calculated (100 sulphate of barium = 34·34 sulphuric acid).

Estimation of the Chlorine.—Two thousand or three thousand grains of the water, according to the quantity of chlorine supposed to be present, are acidified with nitric acid, the chlorine precipitated with nitrate of silver (100 chloride of silver = 24·74 chlorine).

Should the water contain organic matter it should be freed from it before estimating the chlorine, or it would be partly precipitated, together with the silver-salt, thereby increasing its weight; with this view it should be evaporated with carbonate of sodium (perfectly free from chloride of sodium), the liquid filtered from the earthy carbonate precipitated, evaporated to dryness, the residue fused, redissolved in water, nitric acid added, and then precipitated with nitrate of silver.

Estimation of the total amount of Lime and Magnesia, Silicic Acid, and Oxide of Iron.—From 1,000 to 10,000 grains of the water are acidified with nitric acid, and evaporated to dryness at a heat below ebullition. The perfectly dry residue is digested with dilute hydrochloric acid; the silicic acid remains undissolved, having, by the evaporation, been reduced to its insoluble condition. It is separated by filtration, washed, dried, ignited, and weighed. The filtrate which contains the iron, calcium, and magnesium in the form of chlorides, is supersaturated with ammonia, by which oxide of iron is precipitated, and is collected and determined. The calcium is thrown down as oxalate, from the filtrate from the oxide of iron, by oxalate of ammonium, and estimated as carbonate or sulphate, and the magnesium is precipitated from the filtrate from the oxalate of calcium (concentrated, if necessary, by evaporation) with phosphate of sodium, and estimated as pyrophosphate.

Estimation of the Oxide of Iron, Lime, and Magnesia, dissolved in the water by free Carbonic Acid.—One imperial pint of the water is boiled for some time in a flask, the free carbonic acid is thereby expelled, and the substances which it held in solution are precipitated. The operator must be careful not to allow the volume of the water to be much diminished by the boiling, or a portion of *sulphate of calcium* may be precipitated, together with the earthy carbonates; boiling distilled water should be added from time to time. The precipitate is collected on a filter, dissolved in hydrochloric acid, a few drops of nitric acid added, and the oxide of iron, lime, and magnesia separated from each other and estimated as above described.

Estimation of the Lime and Magnesia in the Filtrate from the precipitate produced by boiling.—They are determined as above, the lime being first precipitated by oxalate of ammonium, and the magnesia subsequently by phosphate of sodium; it may be necessary previously to concentrate the water by evaporation. The joint amounts of the oxide of iron, lime, and magnesia, obtained from the precipitate by boiling, and from the filtrate, ought to correspond with the total quantity of these substances found by the previous experiment.

Estimation of the Alkalies.—About 10,000 grains of the water are evaporated to about one half, then mixed with excess of baryta water, filtered, carbonate of ammonium added, again filtered, and the filtrate evaporated to dryness and ignited. The residue contains the alkalies, which are converted into chlorides by the addition of slight excess of hydrochloric acid, and after gentle ignition carefully weighed; the mixed chlorides are dissolved in a small quantity of water, and treated with excess of an aqueous solution of chloride of platinum; the solution, which should have a yellow colour, is evaporated to dryness over the water-bath, and the dry mass is treated with a mixture of ether and alcohol; the crystalline residue, which is the double chloride of platinum and potassium, is collected on a filter which has been previously dried in the water-bath and accurately weighed; it is here washed with alcohol and ether till the whole of the excess of chloride of platinum is removed; it is then dried at 212°, and weighed; it contains 16 per cent. of potassium = 30·56 of chloride. The amount of sodium is calculated from the difference between the quantity of chloride of potassium found and the original weight of the mixed chloride of potassium and sodium analysed.

Determination of the Degree of Hardness of a Natural Water (Clark's process).—By the term *hardness*, as applied to a water, is understood that property which it possesses of decomposing soap and of forming therewith an insoluble compound. All natural waters possess this property in a greater or less degree, but practically the hardening constituents are the earthy salts, viz. the carbonates of calcium and magnesium, chlorides of calcium and magnesium, sulphate and nitrate of calcium, and sulphate of magnesium; the alkaline salts are almost without any effect. Waters which have their origin in chalky soils, where the water charged with carbonic acid percolates through the soil, and readily takes up some of those salts, which are otherwise nearly insoluble, are nearly always very hard; and it is important, therefore, to ascertain how this hardness may be removed, or at any rate lessened, in the cheapest and most effectual manner. Now the *hardness* of a water may be temporary only, or it may be permanent. If the only earthy salts it contains are the carbonates of calcium, or of magnesium, or both, they may be removed by simply boiling; but if the water contain *calcium* and *magnesium only* in the forms of nitrates, sulphates, and chlorides, it cannot be improved by mere boiling, and its hardness is very difficult to remove. If the water contain earthy salts in the forms of *carbonates*, *sulphates*, *nitrates*, and *chlorides*, then it will have its hardness lessened by boiling, precisely in proportion to the quantity of earthy carbonates which it contains.

We are indebted to Dr. CLARK for a very simple method of determining the *degree* of hardness of a water. It consists in ascertaining the quantity of a standard solution of soap in spirit required to produce a permanent lather with a given quantity of the water under examination; the result being expressed in degrees of hardness, each of which corresponds to one grain of carbonate of calcium in a gallon (= 70,000 grains of distilled water) of the water. From the specification of his patent (enrolled September 8, 1851), we gather the following particulars:—

(a.) *Preparation of the Soap-test.*—Sixteen grains of pure Iceland spar (carbonate of calcium) are dissolved (taking care to avoid loss) in pure hydrochloric acid; the solution is evaporated to dryness in an air-bath, the residue is again redissolved in water, and again evaporated, and these operations are repeated until the solution gives to test-paper neither an acid nor an alkaline reaction. The solution is made up by additional distilled water to the bulk of precisely one gallon; it is then called the 'standard solution of 16 degrees of hardness.' Good London curd soap is dissolved in proof spirit, in the proportion of one ounce avoirdupois for every gallon of spirit, and the solution is filtered into a well-stoppered phial capable of holding 2,000 grains of distilled water; 100 test-measures, each measure equal to 10 water grain-measures of the standard solution of 16 degreee of hardness, are introduced. Into the water in this phial the soap-solution is gradually poured from a graduated burette; the mixture being well shaken after each addition of the solution of soap, until a lather is formed of sufficient consistence to remain for five minutes all over the surface of the water, when the phial is placed on its side. The number of measures of soap-solution is noticed, and the strength of the solution is altered, if necessary, by a further addition of either soap or spirit, until exactly 32 measures of the liquid are required for 100 measures of the water of 16 degrees of hardness. The experiment is made a second and a third time, in order to leave no doubt as to the strength of the soap solution, and then a large quantity of the test may be prepared; for which purpose Dr. Clark recommends to scrape off the soap into shavings, by a straight sharp edge of glass, and to dissolve it by heat in part of the proof spirit, mixing the solution thus formed with the rest of the proof spirit.

(b.) *Process for ascertaining the Hardness of Water.*—Previous to applying the soap-test, it is necessary to expel from the water the excess of carbonic acid; that is, the excess over and above what is necessary to form alkaline or earthy bicarbonates; this excess having the property of slowly decomposing a lather once formed. For this purpose, before measuring out the water for trial, it should be shaken briskly in a stoppered glass bottle half filled with it, sucking out the air from the bottle at intervals by means of a glass tube, so as to change the atmosphere in the bottle; 100 measures of the water are then introduced into the stoppered phial, and treated with the soap-test, the carbonic acid eliminated being sucked out from time to time from the upper part of the bottle. The hardness of the water is then inferred directly from the number of measures of soap-solution employed, by reference to the Table on p. 396. In trials of waters above 16 degrees hardness, 100 measures of distilled water should be added, and 60 measures of the soap-test dropped into the mixture, provided a lather is not formed previously. If at 60 test-measures of soap-test, or at any number of such measures between 32° and 60°, the proper lather be produced, then a final trial may be made in the following manner:—100 test-measures of the water under trial are mixed with 100 measures of distilled water, well agitated, and the carbonic acid sucked out; to this mixture soap-test is added until the lather is produced, the number of test-measures required is divided by two, and the double of such degree will be the hardness of the water; for example, suppose half the soap-test that has been required correspond to $10\frac{5}{10}$ degrees of hardness, then the hardness of the water under trial will be 21. Suppose, however, that 60 measures of the soap-test have failed to produce a lather, then another 100 measures of distilled water are added, and the preliminary trial made, until 90 test-measures of soap-solution have been added; should a lather now be produced, a final trial is made by adding to 100 test-measures of the water to be tried 200 test-measures of distilled water, and the quantity of soap-test required is divided by 3, and the degree of hardness corresponding with the third part being ascertained by comparison with the standard solutions, this degree multiplied by 3 will be the hardness of the water. Thus, suppose 84·5 measures of soap-solution were required, $\frac{845}{3} = 28{\cdot}5$, and, on referring to the Table this number is found to correspond to 14°, which, multiplied by 3, gives 42° for the actual hardness of the water.

TABLE OF SOAP-TEST MEASURES, CORRESPONDING TO ONE HUNDRED TEST-MEASURES OF EACH STANDARD SOLUTION.

Degree of Hardness	Soap-test Measures	Differences as for the next Degree of Hardness
0 (distilled water)	1·4	1·8
1	3·2	2·2
2	5·4	2·2
3	7·6	2·0
4	9·6	2·0
5	11·6	2·0
6	13·6	2·0
7	15·6	1·9
8	17·5	1·9
9	19·4	1·9
10	21·3	1·8
11	23·1	1·8
12	24·9	1·8
13	26·7	1·8
14	28·5	1·8
15	30·3	1·7
16	32·0	

When the measures of soap-test necessary to form a lather with 100 test-measures of a water exactly correspond with the standard solution, then the degree of hardness will be the corresponding integral number found in the first column. Thus, 24·9 of soap-test will indicate 12° of hardness, 26·7 of soap-test will indicate 13° of hardness, and so on. But if the measures of soap-test do not exactly correspond with a number in the first column, the hardness will be expressed partly by an integer and partly by a fraction. The *integer* will be the hardness corresponding to the next lower number in the soap-test column. The *numerator* of the fraction will be the excess of the soap-test measures in question above this number. The *denominator* of the fraction will be the corresponding difference which follows the soap-test in the next column.

Example.—Let 25·8 be the measures of soap-test required by 100 test-measures of a given water; 24·9 is the next lower number in the soap-test column; therefore 12° of hardness, the corresponding degree, is the integral part of the required hardness. The numerator of the fraction is $25{\cdot}8 - 24{\cdot}9 = 0{\cdot}9$; the denominator is the corresponding difference $= 1{\cdot}8$. Therefore the *fraction* is $\frac{0{\cdot}9}{1{\cdot}8} = 0{\cdot}5$, and the whole hardness is 12·5°.

To infer the degree of hardness from an ordinary analysis, Dr. CLARK gives the following rule:—Compute the number of grains of lime, magnesia, oxide of iron, and alumina in a gallon of water each, into its equivalent of chalk; the sum of those equivalents will be the hardness of the water. The experiments of Mr. CAMPBELL, however, show that this rule is not always accurate. He found that water containing *sulphate of magnesium alone* acts towards the soap-test in producing with it a perfect lather, similarly, or nearly so, as water containing a *calcium* salt alone, *only* when the equivalent of magnesian salt does not exceed six grains of carbonate calcium in a gallon of water. From that point the magnesian standards begin not to require so much soap-test as the lime; and as the standards increase, this difference in soap-test increases till the magnesian standard of 16° requires only 19·6° soap-tests; whilst the lime standard of 16° requires 32. In standard solutions containing 16°, 12°, 8°, 6°, 4°, 2° lime in a gallon *plus* 1°, 2°, 3°, 4° magnesia, and so on up to 16°, *less* soap-test was requisite to cause a perfect lather in most of the solutions than is requisite for the standard of lime alone contained in them; or, in other words, the magnesia appeared to *soften* the lime standards, and this peculiarity was found to increase as the magnesia increased. For example, a standard of lime of 16° takes 32 test-measures, a standard of lime 16° + 1° magnesia takes 31·6, and a standard of lime 16° + 16° magnesia takes 27·9. It thus appears that when a water contains both magnesia and lime salts (the former in quantity), the degree of hardness of the water cannot be taken as representing the amount of the earthy salts present; neither can it be considered as giving the amount of lime. It is rarely, however, that a water applicable to domestic use occurs in which there is such an amount of magnesia present as to occasion serious disturbances in the indications of the soap-test.

Lastly, to obtain uniform results, Dr. CLARK recommends that as soon as a lather is formed, such as will remain for five minutes, an *interim* note be taken of the quantity of soap-test used. In about half an hour the bottle should be shaken again, to see whether the lather will still remain for five minutes. If the water does not exceed 4° or 5° of hardness, it is likely to require a little more soap-test upon this renewed shaking; but in every case where more soap-test is required, more must be added. This latter quantity and the former will together make up the whole soap-test.

Determination of the Amount of Organic Matter in Water.—This, as Dr. MILLER observes ('Jour. Chem. Soc.', 1865, p. 118), is the most difficult and at the same time most important problem in the analysis of potable water. The plan, often practised, of simply evaporating down to dryness, weighing, and then igniting and weighing a second time, always leads to inexact results, and commonly produces an over-estimate of the amount of organic matter, owing to the loss especially of hydrochloric acid and carbonic acid, if much magnesian salts are present. It is better to add a known quantity of fused carbonate of sodium to the vessel in which the evaporation is being effected, and this is best performed in a thin platinum crucible capable of containing at least three ounces of water, and provided with a platinum cover. When the weight of the dry residue is ascertained, the amount of carbonate added is simply deducted from the weight obtained.

The drying of the residue should be completed in an air-bath, the temperature of which is maintained for one hour at about 300° Fahr. After being carefully weighed, the organic matter is burnt off at a low red-heat, and the residue, when cold, again weighed, the crucible being covered. After the ignition the saline mass should be moistened with a saturated solution of carbonic acid in distilled water, and then again be evaporated to dryness, and the residue maintained for one hour in the air-bath at the same temperature as that employed in the original desiccation.

In this way we shall have ascertained the amount of the soluble constituents (both fixed and organic), as well as an approximative estimate of the amount of organic matter. As an accessory test of the amount of organic matter dissolved in water, a solution of permanganate of potassium may be employed. MILLER recommends a solution such that 10,000 water-grain measures shall, in an acidulated solution, exert an oxidizing power equal to that of *one grain* of oxygen, or 1 cubic centimètre of liquid shall be equivalent to 6·1 milligramme of oxygen. For this purpose 3·95 grains of pure crystallized permanganate in 10,000 grains of water should suffice. This will be equivalent to 0·379 gramme of the salt in a litre of water, but its power may be exactly measured by means of a *freshly-prepared* solution of crystallized oxalic acid containing 7·875 grains in 10,000 measured grains of water or 0·7875 gramme of oxalic acid in 1 litre of water. 100 measures of this solution, warmed with a very dilute solution of sulphuric acid, should decolorize exactly 100 measures of the permanganate. 0·05 gall. (8 oz.) of the water is placed in a flask with 50 grains of diluted sulphuric acid (1 of acid to 3 of water); 20 grains of the permanganate solution may then be added, the flask being placed on a white ground in front of a window. At intervals of fifteen minutes it is examined, and successive quantities of 10 or of 5 grains of the permanganate solution are added in proportion to the rapidity and completeness with which the colour disappears. These successive additions of permanganate must be made until the last addition remains sensibly unaltered after the lapse of half an hour, which generally occurs between two and three hours from the commencement of the experiment. The number of water-grains consumed is then ascertained, and on multiplying this number by 20 we have the quantity of oxygen in $\frac{10}{1000}$ths of a grain consumed in oxidizing the organic matter in 1 gallon of the sample of water.

Estimation of Ammonia in Potable Water.—This, which is a point of importance, is readily effected as follows (Miller, 'Jour. Chem. Soc.' vol. xviii. p. 135):—Into a capacious retort a quart of the water is introduced, and the retort connected with a suitably mounted Liebig condenser; an ounce of baryta-water is then added, and 10 ounces of water are distilled over slowly; or 1 litre of water may be used, 25 c.c. of baryta-water, and 250 c.c. of water distilled over. The residue in the retort is filtered, and separated from the carbonate and sulphate of barium. The distillate is divided into two equal portions: one of these is submitted to Nessler's test for ammonia in the following manner, as recommended by Mr. Hadow:—Make a concentrated solution of an ounce or more of corrosive sublimate; having dissolved 2½ ounces of iodide of potassium in about 10 ounces of water, add to this the mercurial solution until the iodide of mercury ceases to be dissolved on agitation; next dissolve 6 ounces of solid hydrate of potash in its own weight of water, and add it gradually to the iodized mercurial solution, stirring whilst the mixture is being made; then dilute the liquid with distilled water till it measures 1 quart. When first prepared, it usually has a brown colour of greater or less intensity, owing to the presence of a little ammonia, but if set aside for a day or two it becomes clear and nearly colourless; the clear liquid may then be decanted for use. For a litre of the test liquid of equal strength, 62·5 grammes of iodide of potassium and 150 grammes of solid caustic potash will be required. About 50 grains (3 c.c.) of this solution are drawn off by a marked pipette and added to one-half of the distillate. If no ammonia be present, the mixture remains colourless; but if ammonia be present, the liquid will assume a yellowish tinge of greater or less intensity. The liquid will remain clear if the ammonia does not exceed $\frac{1}{200}$th of a grain in the 5 ounces, or about 0·25 milligramme in 125 grms. of the distillate. The quantity of ammonia in such a case may be very accurately estimated in the following manner:—A solution of sal ammoniac is prepared containing 3·17 grains of the salt in 10,000 grains of water (or 0·317 gramme of the salt per litre), which is equivalent to $\frac{1}{1000}$th of a grain of ammonia in each grain of this solution, or 0·1 gramme in 1 litre. Suppose that a tint is obtained in the distilled liquid which experience leads the observer to estimate say at $\frac{5}{1000}$ths of a grain. 50 grains of the standard sal ammoniac solution are placed in a beaker similar in size to that used for the distillate under trial, then diluted with 5 ounces of distilled water previously ascertained to be free from ammonia (an impurity not unfrequently met with in the first portions of water which come over in distillation); lastly, 50 grains of the mercurial test-liquor are added. If the tint coincides in intensity with that furnished by the distillate which has received an *equal quantity* of the mercurial test, the amount of ammonia may be considered to correspond with that taken in the liquid for comparison; if the distillate appear to have a deeper or a paler tint, a second approximative trial with a larger or a smaller quantity of sal ammoniac must be made, and so on, until the operator is satisfied that the tints coincide. On multiplying the number of grains of sal ammoniac solution by 8, the product will give in $\frac{10}{1000}$ths of a grain the quantity of ammonia per gallon in the water under examination.

Example.—Suppose the amount of ammonia in the 125 c.c. operated upon to be estimated at 0·25 milligramme, the observer takes 2·5 c.c. of the sal ammoniac solution and dilutes it with distilled water to 125 c.c.; he then adds 3 c.c. of the mercurial liquor, and compares it with the tint produced in the distillate by a like addition of the mercurial test. If the two tints correspond, multiply by 2 the number of c.c. of sal ammoniac solution required, and the number obtained will give the proportions of ammonia per litre in 10ths of a milligramme.

When the quantity of ammonia exceeds the 20th of a grain pĕr gallon, or 0·6 milligrammes per litre, it is necessary to determine the amount by neutralization; and it was to provide for this contingency that the second half of the ammoniacal distillate was directed to be reserved.

The Test Acid.—Mix 2·882 grains of oil of vitriol with 1,000 grains of distilled water, or 2·882 grammes with 1 litre; a liquid is thus obtained, 1 grain of which will neutralize $\frac{1}{10000}$th of a grain of ammonia, or 1 c.c., will be equivalent to 1 milligramme. The neutralization is effected in the ordinary way (see *Alkalimetry*), using infusion of litmus to indicate the point of transition from alkalimity to commencing acidity.

Messrs. WANKLYN and CHAPMAN, in their excellent little practical treatise on the 'Examination of Potable Waters,' have described some important modifications of the above-described method of determining the amount of ammonia in water. 'Most kinds of water,' they observe, 'contain ammonia (or ammoniacal salts), which either was recently or will presently become a constituent of organic matter. In addition to this, many kinds of water actually do contain more or less nitrogenous organic matter, which furnishes ammonia either on simple boiling with carbonate of sodium or else on boiling with permanganate of potassium in presence of excess of alkali. By estimating the amount of ammonia obtainable from water, noting the circumstances under which it is obtained, we have a measure of the nitrogenous organic matter present in water.' The following is their mode of procedure:—

'Half a litre of the water is placed in a tubulated retort, and 15 c.c. of a saturated solution of carbonate of sodium added. The water is then distilled until the distillate begins to come over free from ammonia (i.e. until 50 c.c. of distillate contain less than $\frac{1}{100}$th of a milligramme of ammonia). A solution of potash and permanganate of potassium is next added. This solution is made by dissolving 200 grms. of solid caustic potash and 8 grms. of crystallized permanganate of potassium in a litre of water. The solution is boiled to expel any ammonia, and both it and the solution of carbonate of sodium ought to be tested on a sample of pure water before being used in the examination of water.'

50 c.c. of this solution of potash and permanganate should be used with half a litre of the water to be tested. The distillation is continued until 50 c.c. of the distillate contain less than $\frac{1}{100}$th milligramme of ammonia. Both sets of distillate have the ammonia in them determined by means of the NESSLER test, as described above.

A standard ammonia solution containing $\frac{1}{100}$th of a milligramme of ammonia in 1 cubic centimètre may be made by dissolving 0·03882 grm. of sulphate of ammonium in a litre of water. Practically, however, it is convenient to keep a solution of ten times this strength (0·3882 grm. of sulphate of ammonium in a litre of water), and to dilute it when required for use.

The colour observations of the NESSLER determination are best made in narrow glass cylinders of such a diameter that

100 c.c. of the water to be tested form a stratum about 7 inches deep. The depth of tint is best observed by placing those cylinders upon a sheet of white paper near a window, and looking at the surface of the liquid obliquely.

Estimation of Nitrogen existing as Nitrates and Nitrites.—For this purpose Frankland employs a modification of a process proposed twenty years ago by Walter Crum for the refraction of nitre ('Phil. Mag.' xxx. 426). It consists in agitating with mercury a concentrated solution of the nitrate or nitrite with a large excess of concentrated sulphuric acid, when the whole of the nitrogen is evolved as nitric oxide. For the details of this method the reader is referred to the elaborate memoir on the Analysis of Potable Waters, by Frankland and Armstrong, published in the 'Journal of the Chemical Society' (vol. xxi. p. 77). In the same volume will be found a description of the equally exact method proposed by Chapman, which depends on the reduction of the nitric acid to ammonia by means of aluminum in an alkaline solution, and the measurement of the ammonia formed either by the Nessler test or by titration. The process is conducted as follows:—The first thing to be done is to obtain some idea of the quantity of nitrate contained in the water. For this purpose boil a little of it in a flask with caustic soda, free from nitrate, until a sample of it does not colour the Nessler test, and then introduce a slip of aluminum foil. As soon as this is dissolved, decant the liquid into a test-tube, add the Nessler test, and note the colour produced. Should it be very dark, or should a precipitate be formed, either very little of the water (10 c.c. to 25 c.c.) must be employed, or a tolerably large quantity, and the ammonia produced determined by titration (see *Alkalimetry*); if, on the other hand, the colour is very pale, 200 c.c. will be a convenient quantity to employ. For common waters, 100 c.c. is ample.

Having learnt what sort of water is in hand, measure off the volume indicated by the preliminary experiments; introduce it into a non-tabulated retort, and add 50 to 70 c.c. of a solution of caustic soda containing 100 grms. of soda in the litre. If very little water has been used, add some distilled water. The contents of the retort are now to be distilled until they do not much exceed 100 c.c., and until no more ammonia can be detected in the distillate by the Nessler test. The retort is now cooled, and a piece of aluminum foil introduced. The neck of the retort is now inclined a little upwards, and its mouth closed by a cork, through which passes the narrow end of a small tube filled up with broken-up tobacco-pipe, wet either with water or with very dilute pure hydrochloric acid. This tube need not be more than an inch and a half long, nor larger than a goose-quill. It is connected with a second tube, containing pumice-stone moistened with strong sulphuric acid. This last tube serves to prevent any ammonia from the air from entering the apparatus, which is allowed to stand in this way for a few hours or over night. The contents of the pipe-clay tube are now washed into the retort with a little distilled water, and the retort is adapted to a condenser, the other end of which dips beneath the surface of a little distilled water (about 70 to 80 c.c.). The contents of the retort are now distilled to about half their original volume. The distillate is made up to 150 c.c.; 50 c.c. of this are taken out, and the NESSLER test added to them. If the colour so produced is not too strong, the estimation may be made at once; if it is, the remainder of the distillate must be diluted with the requisite quantity of water. Should it be desired to determine the ammonia by titration, half a litre of the water must be evaporated down to a small bulk, and this small bulk treated in exactly the same manner, except that the distillate is received in dilute standard sulphuric acid instead of water.

The presence of *nitrites* in the well waters of towns is not unusual. The reactions of the nitrites upon iodide of potassium and starch employed by Dr. DAVID PRICE as a test for the iodides may be used conversely to detect traces of nitrites in waters, which it will reveal when the amount of nitrite pressure is considerably less than a grain per gallon. It is merely necessary to add to a little dilute starch a few drops of a weak solution of iodide of potassium, and then a few ounces of the water slightly acidulated with dilute sulphuric acid; an instantaneous blue colouration of the starch by liberated iodine will occur if the water contains any sensible amount of nitrite. The quantity of nitrites may be approximately estimated by the amount of a graduated solution of permanganate, which a given measure of the water (say 0·05 gallons, or 250 c.c.) will bleach. When the solution of permanganate of potassium is employed to determine the amount of organic matter, if nitrites be present, part of the permanganate will be destroyed by their action; the bleaching, though not absolutely instantaneous, takes place in a few seconds; and therefore it can be at once distinguished and measured separately from the reducing effect occasioned by the organic matter, which is always very gradual. The discolouration of 1 grain of a solution of permanganate containing 3·95 grains of the crystallized salt in 10·000 grains of water would represent 0.00237 grains of nitrous acid, or 1 c.c. would be equivalent to 0·237 milligramme.

To convert the report of the number of grains per gallon (70,000) into parts in 1,000,000 (or what amounts to the same thing, to milligramme per litre), divide the results by 7, and multiply by 100. If the quantities per litre have been obtained in milligrammes, the proportion in grains per gallon is given by the converse operation of dividing by 100 and multiplying by 7.

Detection and Estimation of Lead.—This fortunately is attended with no difficulties, though certain precautions are necessary when the water contains (as almost all natural waters do, more or less) soluble organic matters. We possess in sulphuretted hydrogen a test, by which the presence of $\frac{1}{4}$ of a grain of lead is indicated in 1 gallon of distilled water by the production of a brown tinge. In making the experiment, the beaker should be placed on a sheet of white paper, and a second beaker, to which no sulphuretted hydrogen has been added, should be placed by its side, also on white paper, so that the faintest brown tinge may be rendered evident by comparison; a few drops of pure hydrochloric acid should be added previous to the application of the test. Dr. SMITH, in his investigation of the action of the waters of the Dee and the Don on lead pipes and cisterns, employed the tint produced by sulphuretted hydrogen as a means of estimating, quantitatively, the amount of lead deposited in water. 1·6 grains of nitrate of lead were dissolved in 1,000 grains of distilled water; a solution was thus prepared, 1,000 grains of which contained 1 grain of metallic lead. From an accurately graduated measure, this solution was dropped into a gallon of water containing no lead, until a transmission of sulphuretted hydrogen, the same depth of tint, was developed as in the particular case on trial. Very accurate results are said to have been obtained, until the quantity of lead exceeds $\frac{1}{4}$ grain per gallon, when the colour gets so dark that slight differences cannot be discriminated: $\frac{1}{400}$th of a grain of lead to a gallon of pure water gave a tint quite perceptible, that is, one of metallic lead in *seven millions*, and a less quantity could readily be distinguished by careful comparison, even in specimens previously containing a considerable proportion of lead, the difference of $\frac{1}{100}$th of a grain was plainly visible. The presence of organic matter in solution in water interferes materially with the action of sulphuretted hydrogen on the lead which it may contain; and as Dr. SMITH informs us that nearly one-half of the solid matter in the water of the river Dee consisted of organic matter, it would appear that the method he describes could not give very reliable quantitative results. Previous to applying the sulphuretted hydrogen test, the water should be carefully evaporated to dryness, and the residue ignited in a small porcelain capsule, whereby the organic matter is destroyed. The saline matter should be moistened with nitric acid, and then warmed with the addition of acetic acid and water, and, if necessary, filtered. To estimate the amount of lead *quantitatively*, a gallon of the water should be employed; it should be gently evaporated to dryness, and the residue having been moistened with a few drops of nitric acid and ignited, is digested with dilute hydrochloric acid and filtered. The solution is neutralized with carbonate of sodium, and acidified with acetic acid; a small quantity of bichromate of potassium is then added, and the liquid set aside for some hours. If a yellow precipitate is produced, it is *chromate of lead*, which is redissolved in hydrochloric acid, and tartaric acid and excess of ammonia having been added, sulphuretted hydrogen is passed through the solution. The precipitated sulphide of lead is washed by decantation, and converted into sulphate by evaporating to dryness with a little fuming nitric acid, and a drop or two of sulphuric acid. The ignited residue contains 73·6 per cent. of oxide of lead.

WAX.—Wax is a product secreted by bees; or rather, fabricated by bees from honey or sugar. It is obtained after expressing the honey from the combs by melting the latter into cakes, in which state it constitutes the yellow beeswax of shops. Unbleached beeswax is yellowish brown; has an odour of honey, and is tasteless. When bleached it is perfectly white, and has a salvy odour.

Both yellow and white wax are often adulterated with earthy matter, such as chalk, sulphates of calcium, of barium, and sodium, carbonate of barium, &c.; or with flour, starch, resin, oxide of lead, of zinc.

Most of these admixtures may be detected by boiling the wax in water, which will separate all the heavier substances; such as chalk, sulphate of calcium, barium, and other earthy matter, the oxide of lead, of zinc, &c. Sulphate of sodium will dissolve, and and on cooling the wax will be found in the solid state floating on the water.

If the wax has been adulterated with flour or fecula, the water in which the wax has been boiled will be more or less thick, and after cooling it will produce a blue colour with solution of iodine. Or all these impurities may be estimated directly by fusing the wax *per se* in a capsule, and on leaving it at rest the impurities will subside, and be found at the bottom of the capsule. And, moreover, if starch or flour be present, the wax being treated by concentrated sulphuric acid will turn black, because the acid will then char the starch or flour.

Beeswax is sometimes adulterated by *resin;* this fraud may be detected because, in that case, the fracture will be smooth instead of granular, and if heat be applied the odour of resin becomes perceptible. That odour is sometimes readily recognised in the cold. A cotton wick, dipped into fused genuine beeswax, burns with a clear white flame; but if resin be present, the flame is fuliginous and smoky.

The adulteration of beeswax with *tallow* is more difficult of detection, but the presence of the latter substance may be recognised by dipping a cotton wick into the fused beeswax under examination, lighting it, and after a few seconds blowing it out, when the odour of tallow will become perceptible. According to BOUDET and BOISSENOT, this fraud may also be detected by submitting the suspected wax to dry distillation, for pure wax yields no sebacic acid, whilst if it contains 2 per cent. of tallow sebacic acid is obtained, and may be recognised as such, because the water into which the products of the distillation have been digested, and which should be perfectly pure, has acquired the property of being precipitated by a solution of neutral acetate of lead, and also by the salts of silver and of mercury.

Bleached beeswax which has been adulterated by tallow, instead of being semi-transparent and hard, is more opaque and softer.

WHITE ARSENIC. *See* ARSENIC.

WHITE COPPER. *See* GERMAN SILVER.

WHITE COPPERAS. *See* ZINC.

WHITE LEAD. *See* LEAD.

WHITE OXIDE OF ARSENIC. *See* ARSENIC.

WHITE VITRIOL. *See* ZINC.

WHITE ZINC. *See* ZINC.

WINES.—Wine is a liquid resulting from the alcoholic fermentation of the juice of the grape, but for which gooseberries, currants, and other fruits are often substituted. These are generally called 'British wines.'

It sometimes happens that wine which has been kept too long, or in too warm a place, becomes acid, and instead of being sold as it should be to the vinegar-maker, it undergoes in the hands of certain unprincipled dealers a *doctoring* which, removing, neutralizing, or masking this acidity, allows of its being mixed with other wines, or with alcohol, after which it is sold to the inexperienced or incautious as genuine wine. The substances employed to neutralise the sourness of wines are *carbonate of* *sodium*, of *potassium*, or of *calcium*; but as these substances give a dark, or even a black colour to the wine, and hasten the putrefactive fermentation, *litharge*, *carbonate of lead*, or *metallic lead*, is sometimes employed, the result being the formation of acetate of lead (sugar of lead), which is a salt of a sweet taste, which does not alter the colour of the wine, and which, moreover, has the property of checking fermentation. This most dangerous practice, however, is much less frequent than formerly, when the poisonous properties of acetate of lead were not so well known as now.

The above substances may be detected in wine in the following manner:—

When wine has been sophisticated with *carbonate of calcium*, the addition of oxalate of ammonium invariably produces a precipitate of oxalate of calcium. Yet, though oxalate of ammonium may produce such a precipitate, the operator should not hastily conclude that the wine has been saturated with carbonate of calcium, because genuine wine contains tartrate of calcium, and will therefore produce a precipitate of oxalate of calcium when tested by oxalate of ammonium; but in the latter case, that is, if the wine be genuine, the precipitate produced is trifling, whilst in the contrary case it is abundant. The fact may, however, be placed beyond doubt by evaporating a portion of the wine to about one-eighth of its bulk, and diluting it then with its own bulk of alcohol, which will separate the tartrate and sulphate of calcium which may exist naturally in the wine, whilst the acetate of that base remains in solution. The wine should then be filtered, and the filtrate evaporated to dryness. The dry residuum is next redissolved in water and filtered. If now the filtrate, being tested with oxalate of ammonium, produces an abundant precipitate of oxalate of calcium, the presence of acetate of lime is rendered conclusive.

If *carbonate of potassium* has been employed to saturate the excess of acetic acid, the presence of acetate of potassium may be rendered manifest as follows:—A portion of the wine is evaporated to syrupy consistence and stirred with a small quantity of alcohol, which dissolves all the acetate of potassium with the help of a gentle heat, and the liquor is filtered. The alcoholic filtrate, which has a yellowish-red colour, should be divided into two portions; one of these portions is tested with solution of chloride of platinum. If this produces a granular precipitate of a lemon-yellow colour, it is a proof of the presence of potassium. The second portion should be evaporated to dryness, and the dry residuum, treated by concentrated sulphuric acid, will then disengage vapours of acetic acid, recognizable by their odour. It is true that genuine wine, containing always some acetate of potassium, behaves in the same manner when so treated; but the quantity of acetate of potassium existing naturally in the wine is so small, that chloride of platinum creates only a turbidness or a very slight precipitate, and the vapours of acetic acid evolved by treatment with concentrated sulphuric acid are very trifling.

If the wine has been saturated with *carbonate of sodium*, the residuum left after evaporation should be treated by weak alcohol, in order to dissolve the acetate of sodium; and, on evaporating, acetate of sodium will be obtained in crystals, which, heated before the blow-pipe, will impart a deep yellow tinge to the flame, and which, when treated by concentrated sulphuric acid, will evolve pungent vapours of acetic acid.

If *lead* or its *carbonate*, or *litharge*, has been employed to saturate the acid of the wine, the detection is very easy and conclusive. A portion of the wine is evaporated to dryness, the organic residuum is charred, triturated with twice its weight of nitre, and decomposed by projecting it by small portions at a time in a red-hot capsule or crucible. If the ignited mass should still have a brown colour, it should be triturated with a fresh portion of nitre and ignited again. After fusion, the residuum is treated by very dilute nitric acid in order to dissolve it, and if a portion of the solution, which is almost colourless, being treated by sulphuretted hydrogen, produces a black or dark brown precipitate; and if another portion of the solution, being tested with a solution of chromate of potassium, produces a yellow precipitate, and a white one when tested by solution of carbonate, or of sulphate of potassium, of sodium, or by ammonium, the presence of lead is certain. The presence of lead in wine may also be detected by testing with solution of oxalic acid; the precipitate produced is collected on a filter, or separated by decantation; it is then heated upon charcoal before the blow-pipe; the first impression of the heat causes the mass to emit fumes; it becomes white, and finally a bead of metallic lead remains, which may be seen either with the naked eye or with the help of a magnifier. Generally, however, the quantity of lead is too small to be detected in this manner.

The practice of rinsing wine-bottles with lead-shot is sometimes attended with serious consequences, on account of some of the shots being carelessly left in the bottles, or jammed by the shaking in the fold or circular depression at the bottom of the bottle, where they may be left unperceived. There are several cases on record of persons having been seized with violent cholic, with all the symptoms of poisoning, from having drunk wine which had thus become deleterious, the few shots thus accidentally left having gradually become converted into acetate and carbonate of lead.

As to *alum*, which is sometimes added to wine for the purpose of brightening its colour, or of clarifying newly-made wine, its presence may be detected by first decolorizing the wine (if red wine) by means of animal charcoal, previously washed with hydrochloric acid, filtering, and evaporating the lead to about one-third of its volume, in a porcelain or platinum capsule, and again filtering it. If a precipitate has been produced whilst concentrating it, if solution of potash, or of ammonia, or of sal-ammoniac produce, when poured into the filtrate, a white precipitate soluble, with the help of heat, in an excess of solution of caustic potash; if carbonate of potassium or of sodium produce a white precipitate; if solution of nitrate of barium, or of chloride of barium, produce also a white precipitate, insoluble in water and in acids, then the wine contained alum.

Or a given portion of the wine may be evaporated to dryness and ignited; the ignited residuum is then treated by a small quantity of hydrochloric acid, evaporated to dryness, again treated by dilute hydrochloric acid. If the addition of solution of caustic potash to the acid solution produces a white bulky precipitate soluble in an excess of caustic potash, but which is reprecipitated by a solution of sal ammoniac, then *alum* is present.

A small quantity of *sulphuric acid* is sometimes added to wines; its presence in the free state may be detected by pouring a drop or two of the suspected wine upon a piece of paper, and drying it at a gentle heat. The wine, if pure, leaves the paper unaltered, but if it contain sulphuric acid, the paper will be corroded and crumble into fragments, on rubbing between the fingers the part which has thus been moistened.

M. LASSAIGNE says also, that pure wine leaves by spontaneous evaporation a violet or purple stain on the paper, whilst that to which sulphuric acid has been added (from 2 to 3000ths) leaves a pink stain in drying.

The paper best suited for such experiments is common glazed paper containing starch; or it may be prepared by painting it, as it were, with thin paste.

But the most frequent adulteration consists in an addition of water and of alcohol. There is no satisfactory method of detecting this fraud when the wine, after having been sophisticated in this matter, has been allowed to remain undisturbed for some considerable time, and when perfectly pure sugar-spirit has been employed for the purpose. The best test in such cases is a good palate. But when the spirit employed is ordinary spirit, which is generally the case, the adulteration may be detected by distilling a portion of the wine, and rubbing between the hand a small quantity of the spirit which distils over. If the wine was pure, no other odour is discernible but that of pure spirit; in the contrary case, a peculiar odour (that of oil of grain, or fused oil) becomes apparent.

The quantity of alcohol contained in wine may be determined also by distillation, and taking the specific gravity of the distillate. To effect this, four or five ounces by measure of the wine in question are put into a small still or retort, and a sufficient quantity of caustic soda added to entirely change the colour of the wine. The retort is adapted to a LIEBIG's condenser, connected with a glass balloon. About two-thirds of the wine are distilled over, and when the distillate has completely cooled, its specific gravity is then taken at 60° Fahr., by means of a 1000 grains specific-gravity bottle or otherwise. Let us suppose that on weighing the contents of the specific gravity bottle, it is found to be 960 grains; reference to the Tables given in the article on *Acohol* will show that spirits of specific gravity 0.960 contain 40.1 per cent. of spirit under proof, or 29 per cent. of absolute alcohol of specific gravity 0·7960, and hence the quantity of alcohol contained in the wine operated upon is easily calculated.

Hitherto we have spoken only of the adulterations to which genuine wine is subjected. We have now briefly to consider the *simulations* of wine, that is to say, the sophistications in which wine, instead of being the principal constituent, is, as it were, the adventitious substance.

Among other receipts for the manufacture of port wine, the following have been given :—

'To manufacture port wine, put into a cask, previously sulphurized—

12	gallons of	strong port.
6	”	rectified spirit.
3	”	Cognac brandy.
42	”	fine rough cyder.
63	gallons.	

And again another directs :—

45	gallons of	cyder.
6	”	brandy.
8	”	port wine.
2 2	”	Sloes, stewed into two gallons of water, and the liquour pressed off.
63	gallons.	

'If the colour is not good, tincture of red sanders-wood or cudbear should be added.' Oak bark, elder, brazil-wood, privet, beet, litmus, are all used to make these spurious wines, some of which do not even contain the smallest particle of wine.

These adulterations, and the colouring matter employed in making them, may be detected in various ways:—First of all, when spirit has been employed in the *manufacture* of wine, it may generally be detected by the odour of the liquid, and also by that of the distillate, as before observed. If the proportion is at all considerable, as in the above receipts, its presence may be readily detected by throwing a portion of the suspected wine upon brightly ignited charcoal, when a species of deflagration will take place. If the wine is falsified with cyder or with perry, evaporate the wine at a steam heat to a syrupy consistence, and allow the whole to cool without stirring; at the end of 24 hours the clear liquor should be decanted from any crystals of cream of tartar which may have formed; the decanted liquid is diluted with pure distilled water and evaporated as before. The crystals, if any have formed, are again separated by decantation, and the operation is repeated until no more crystals are formed. The syrup which is left at the end of the experiments has the characteristic taste of the apple or of the pear.

It should be remarked also that cream of tartar being one of the constant constituents of genuine wine, any wine in which this substance would be found wanting might at once be pronounced spurious *ipso facto*; or if the quantity of tartar were found very much below the usual quantity, or above it, the wine might be safely considered as having been either diluted with a mixture of alcohol and water, or adulterated with cream of tartar, probably to simulate that which should have been naturally present. In order to detect the tartar and determine its proportion, proceed as follows:—Take a given quantity of the wine under examination—a pint, for example—evaporate to dryness, and ignite the residuum; the tartar (bitartate of potassium) is thereby converted into carbonate of potassium, which being examined by test sulphuric acid (see *Alkalimetry*), will indicate the proportion of bitartrate of potassium to which the carbonate corresponds. 1,000 grain-measures of the test sulphuric acid employed—containing, for example 40 grains—or one equivalent of sulphuric acid, will therefore indicate, if saturated, 180 of cream of tartar.

According to CHEVALLIER, the colouring matter employed for adulterating wine may be detected by solution of caustic potash as follows:—A solution of caustic potash is to be added to the suspected wine in sufficient quantity to saturate the acid of the wine.

If the colour of the wine is genuine no precipitate will be formed, but the colour will change, first from red to bottle-green, and after some time to brownish-green or brown. This colour differs from that produced when an artificial colouring matter has been employed; for example:—

Wine coloured by the following substances	Colour produced by Potash
Elder-berries	Purple.
Logwood	Reddish-purple.
Red mulberries.	Purplish.
Brazil-wood	Red.
Beet-root juice.	Red.
Litmus	Light violet.
American grape (*Phitolaca decandra*)	Yellow.

But none of these substances will yield the greenish or dark green colour which genuine wine assumes under this treatment.

When wine has been coloured with a decoction of the petals of the red poppy, by logwood, or by Brazil-wood, the fraud, according to the experiments of M. Jacob, may be recognised by means of a solution of sulphate of aluminum (10 parts of sulphate in 100 parts of water) mixed in equal proportions with the wine to be tested (that is to say, one fluid drachm of each), and a few drops of solution of carbonate of ammonium are then poured into the mixture. (The solution of carbonate of ammonium is made by dissolving eight parts in weight of carbonate of ammonium in 100 parts of water). The addition of the carbonate of ammonium determines a precipitate, or imparts a tinge variously coloured to the wine, if it have been adulterated; whilst, if genuine, only a greyish-white precipitate is produced, as may be seen hereunder:—

Pure wine	Slightly coloured. Greyish-white.
Pure wine mixed with Brazil-wood	Carmine, red, or pink precipitate, more or less intense, according to the extent of the adulteration.
Pure wine mixed with logwood.	Fine dark purple precipitate.
Pure wine, and petals of red poppies	Slate-coloured precipitate, more or less intense.

Two drops of an infusion made with eight parts of one of these substances in 250 parts of water, are sufficient to produce a very clear reaction when mixed with one fluid drachm of wine.

Vogel proposed the solution of basic acetate of lead to detect when colouring matter has been added to wine.

Pure wine	Greyish green.
Pure wine mixed with Brazil-wood or elder-berries.	Indigo blue.
Pure wine mixed with beet-root juice or sandal-wood.	Red precipitate.
Pure Madeira wine	Light yellow, or cream-coloured precipitate.
Pure port wine	Greyish, with a slight tinge of green.

With logwood, concentrated . .	Crimson red.
„ „ diluted . . .	Leaden, or bluish colour.
With beet-root juice—concentrated.	Pure colour.
„ „ diluted.	Flesh colour.

Berzelius, however, asserts that the colour of the precipitate varies with the age of the wine tested.

According to M. Nees van Esenbeck, the best method of detecting the colouring matter of spurious wines consists in making two solutions; the first with one part of alum and eleven parts of distilled water; the second with one part of carbonate of potassium and eight parts of water.

A determined volume of the wine to be tested is mixed with its own bulk of the alum-solution, and carbonate of potassium is gradually poured into it, taking care, however, not to decompose the whole of the alum. The alumina is thereby precipitated, but as it unites with the colouring matter of the wine, the precipitate is variously coloured, according to the species of colouring matter with which it is combined.

With pure wine	Dingy-grey precipitate, partly soluble in an excess of the reagent, in new wines.
Wine coloured with the petals of the red poppy.	Greyish-brown precipitate, becoming black by excess of alkali.
Wine coloured by privet-berries.	Purplish-brown precipitate.
„ „ myrtle-berries.	Greyish-blue precipitate.
„ „ elder-berries.	Purple precipitate.
„ „ Brazil-wood.	Violet-grey.
„ „ logwood.	Pink.

From the above Table we may conclude that all those wines which, being treated by solution of alum and of carbonate of potassium, yield precipitates of a blue, violet, or pink colour, may be suspected of having been artificially coloured.

Adulteration of Sherry.—The following particulars in reference to the *plastering* and *fumigation* of wine, as well as the manufacture of sherry generally, are taken from a letter by Dr. THUDICHUM, which appeared a short time since in the *Times*:—

'Each quantity of collected grapes sufficient to yield a butt of *must*, previous to being trodden and pressed, is invariably dusted over with from 30 to 40 lbs. of burnt *plaster of Paris* (sulphate of calcium). The effect of this practice is to precipitate all the tartaric and nitric acids of the must, and to substitute in their place sulphuric acid. The *must*, therefore, as it runs from the press, contains no bitartrate of potassium, or so called tartar, but sulphate of potassium instead. In consequence nearly all sherries contain nearly the whole of the potash of the *must* as sulphate, amounting to from 1½ kilogramme (about 3 lb.) to 7 kilogrammes (about 14 lb.) per butt of 484 litres, or 108 gallons (equal to from 36·1 to 169·2 grains per bottle of one-sixth to a gallon).

'The common varieties of *must* are not only plastered, but also impregnated, with the fumes by combustion of about five ounces of sulphur per butt, which adds about a pound of sulphuric acid to that brought in by the plaster. Quantitative determinations, made upon many and different specimens of must at Xerez show that its specific gravity varies between 9° and 14° of Beaume's areometer, indicating from 14·6 to 24 per cent. of sugar, and that therefore it can by fermentation only form from 14 to 25 per cent. of proof spirit.

'The must ferments in the sheds called *bodegas*, there being no cellars properly so called at Jerez. In a fortnight the sugar has all fermented away, and the must is transformed into wine. This is allowed to deposit its lees during some months, and is racked in the following February or March. On this occasion some brandy is added to the wine, by which its alcoholity rises to about 29 per cent of proof spirit. In spring and early summer the wine (still termed '*mosto*,' and so to the time of the next harvest) undergoes what is termed its first "evolution," and after that is ready for further preparation.

'This consists in the addition of various ingredients, which impart colour, sweetness, spirit, and flavour. Colour is imparted by the addition of caramel produced by the boiling down in coppers of previously *plastered* grape-juice; the brown syrup is dissolved in wine and spirit, so as to form a deep brown liquid containing from 35 to 40 per cent. of proof spirit termed "color." or "vino de color." Frequently caramel made from cane-sugar is used instead of that made from grapes. Sweetness is imparted by the addition of "dulce"—that is most frequently made from grapes dried for some days in the sun, to which one-sixth of its volume of spirit, of the strength of 40°, by CARTIER'S alcoholometer, has been added (a process by which all fermentation becomes impossible). Every 100 litres of dulce contain, therefore, 19 litres of absolute alcohol, equal to 33·78 per cent. of proof spirit. Flavour is imparted by the addition of some old selected wine, which is kept on so-called "Soleras." Ultimately brandy is added to the mixture to the extent of fortifying it up to 35 as the *minimum*, most frequently up to 40 or 42, and sometimes up to 10 per cent. of proof spirits.

'In a butt of ordinary sherry (40 jars) there is mostly one-fifth of its volume of dulce (eight jars), consequently about one-sixth of unfermented grape-juice, and which remains unfermented. The better sherries are made less sweet, and only the few finest varieties are left unsweetened. The dulce is never plastered, and therefore its addition depresses a little the large quantity of sulphate of potassium introduced by the "color."

'Sherries contain from $1\frac{1}{2}$ to 8 grammes of sulphuric acid or potash salt per litre (equal to from 17·5 to 93·3 grains per bottle of $\frac{1}{6}$ gallon).'

In an elaborate article on 'Sherry and its Adulterations' in the journal entitled *Food, Water, and Air, in relation to Public Health*, March, 1874, the editor, Dr. ARTHUR HILL HASSALL, gives the results of exhaustive analyses of nineteen different wines, mostly sherries, from which he deduces the following conclusions:—

'1. That the whole of the wines examined are, without exception, *fortified* with extraneous spirit to a large extent, while the average amount of proof spirit furnished by the must from which sherries are made at Xeres, according to the best authorities, is about 19 per cent; the lowest quantity found was about 29·723, and the highest 41·294, the mean of all the analyses being 35·477. In fact the quantity of spirit added falls not very far short of that actually furnished by the fermentation of the grape-juice itself.

'2. That seventeen of the nineteen samples of the wine were decidedly *plastered*. The quantity of sulphate of potassium found in the wines after deducting *three* grains per bottle, being the utmost amount ever met with in natural sherry, ranged from 15 grains per bottle to 51·6 grains. These quantities give 90 grains as the lowest, and 309·6 grains as the highest, amount per gallon. It will be seen, therefore, that these analyses bear out the statement of Dr. THUDICHUM that all the sherries imported into this country are plastered, that is to say, the must is dusted over with plaster of Paris (sulphate of calcium), in addition to which it is also impregnated with the fumes of burning sulphur, whereby a still further quantity of sulphuric acid is introduced into the wine. Dr. HASSALL found as much as 54·6 grains of sulphate of potassium per bottle of sherry, from which number 18 grains being deducted as the full *normal* amount of that salt ever present, there remain 369·6 grains per gallon, or about $\frac{3}{4}$ths of an ounce. The quantity of sulphate of potassium, therefore, met with in his analyses is much below the larger amount given by Dr. THUDICHUM, namely, rather over $2\frac{1}{4}$ ounces.

'3. That in addition to the *fortifying* and *plastering*, five of the wines analyzed contained considerable amounts of cane-sugar, the presence of which affords of course clear evidence of adulteration.

'4. That two of the sherries—those denominated Hambro' sherries—contained very little wine at all, but consisted chiefly of spirit, sugar, and water, flavoured—in fact, those mixtures could hardly be said to have any claims to be regarded as wines at all.'

Determination of the quantity of Alcohol in Wines.—The following directions are given by Mr. GRIFFIN ('Chemical Testing of Wines and Spirits')*: 50 septems of the wine are introduced into a small plain retort by means of a long tube funnel, and a sufficient quantity of caustic soda added to cause the wine to change its colour entirely; the object of the addition of soda is to neutralize those free acids in the wine which are volatile, and which would otherwise distil over with the alcohol and vitiate the result of the operation. 50 septems of distilled water are then added, and then one grain of *tannic acid*, which prevents intumescence, or the production of glutinous bubbles. The retort is connected with a LIEBIG or other form of condenser, and the distillation conducted at a moderate heat, the liquid not being allowed to boil strongly. The distillate is collected in a small bottle which contains 100 septems, or a *centigallon* when filled to the mark on its neck, and the distillation is stopped when the bottle appears to be about two-thirds full. It is now removed from the distillation-tube and filled to the mark with distilled water, the temperature brought to 60°. It is then stoppered and weighed.

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* Mr. GRIFFIN divides the centigallon into 100 parts, to each of which he gives the name of *septem*, because its capacity is equal to that of *seven* grains of water.

Hence, 100 septems make a centigallon,
1,000 ,, ,, decigallon,
10,000 ,, ,, gallon.

Calculations.—The weight of 100 septems of diluted alcohol prepared from the 50 septems of wine having been determined, the calculations which follow depend upon the manner in which the ascertained quantity of alcohol is desired to be stated. This may be: 1. *The grains of absolute alcohol in* 100 *septems;* 2. *The weight in grains of proof spirit in* 100 *septems;* 3. *The percentage of absolute alcohol by volume in the wine.*

Information respecting the first two points is obtained by referring to the following Table, which Mr. GRIFFIN has kindly allowed to be transferred to this work from his valuable little book on the 'Chemical Testing of Wines and Spirits.' With regard to the last point: the percentage of alcohol by *weight* having been found, the percentage by volume may be found thus: 'Multiply the specific gravity of the mixture by the percentage of alcohol by weight, and divide the product by ·7638; the product of the division is the percentage by volume.'

Example.—The *per cent.* by weight of alcohol in a given spirit is 20, and the specific gravity ·9716: then $\frac{\cdot 9716 \times 20}{\cdot 7938} = 24\cdot 48$ the per cent. by volume.

If the grains of absolute alcohol in 100 septems are required, the numbers are found in column 3, in which the weighings of the centigallon specific-gravity bottle are quoted; and on referring to column 4, the corresponding weight in grains of the absolute alcohol contained in the same measure is given. This number must be doubled to give the weight in grains of the absolute alcohol contained in 100 septems of the wine, because the quantity submitted to analysis was only 50 septems.

If it be desired to know the corresponding weight in grains of *proof spirit* contained in 100 septems of the wine, it may be found in column 5 of the Table, the number having of course been *doubled* to compensate for the dilution of the spirit that was distilled from the wine.

Determination of the Quantity of Sugar in Wines.—If the sugar exists only in the form of *grape-sugar*, the amount is estimated with great accuracy in the following manner:—

Test Liquors:—Copper-test A.—433·125 grains of pure crystallized sulphate of copper are dissolved in water, and the solution made up to one *imperial pint.*

Copper-test B.—2,166 grains of tartrate of potassium and sodium (Rochelle salt), and 1,010 grains of pure caustic soda, both dissolved in water to form 1 imperial pint of solution.

TABLE.

Diluted Alcohol containing from 0 *to* 10 *per cent. by Weight of* ABSOLUTE ALCOHOL.

1 Absolute Alcohol per cent. by weight	2 Specific Gravity of the Diluted Alcohol at 60° F.	3 Weight in Grains of 100 Septems of the Diluted Alcohol	4 Weight in Grains of the Absolute Alcohol in 100 Septems	5 Weight in Grains of Proof Spirit at 60° F. in 100 Septems
0·00	1·0000	700·00	·00	·00
0·05	·9999	699·93	·35	·71
0·11	·9998	699·86	·77	1·56
0·16	·9997	699·79	1·12	2·27
0·21	·9996	699·72	1·47	2·98
0·26	·9995	699·65	1·82	3·69
0·32	·9994	699·58	2·24	4·55
0·37	·9993	699·51	2·59	5·26
0·42	·9992	699·44	2·94	5·97
0·47	·9991	699·37	3·29	6·68
0·53	·9990	699·30	3·71	7·53
0·58	·9989	699·23	4·06	8·24
0·64	·9988	699·16	4·47	9·09
0·69	·9987	699·09	4·82	9·80
0·74	·9986	699·02	5·17	10·51
0·80	·9985	698·95	5·59	11·36
0·85	·9984	698·88	5·94	12·06
0·91	·9983	698·81	6·36	12·91
0·96	·9982	698·74	6·71	13·62
1·02	·9981	698·67	7·13	14·47
1·07	·9980	668·60	7·48	15·18
1·12	·9979	698·53	7·82	15·89
1·18	·9978	698·46	8·24	16·74
1·23	·9977	698·39	8·59	17·45
1·29	·9976	698·32	9·01	18·29
1·34	·9975	698·25	9·36	19·00
1·40	·9974	698·18	9·77	19·55
1·45	·9973	698·11	10·12	20·56
1·51	·9972	698·04	10·54	21·41
1·56	·9971	697·97	10·89	22·11
1·61	·9970	697·90	11·24	22·82
1·67	·9969	697·83	11·65	23·67
1·73	·9968	697·76	12·07	24·51
1·78	·9967	697·69	12·42	25·22
1·83	·9966	697·62	12·77	25·93
1·88	·9965	697·55	13·18	26·78
1·94	·9964	697·48	13·53	27·48
1·99	·9963	697·41	13·88	28·18
2·05	·9962	697·34	14·30	29·03
2·11	·9961	697·27	14·71	29·88
2·17	·9960	697·20	15·13	30·73
2·22	·9959	697·13	15·48	31·43
2·28	·9958	697·06	15·89	32·28
2·34	·9957	696·99	16·31	33·12

Table—(*continued*).

1 Absolute Alcohol per cent. by weight	2 Specific Gravity of the Diluted Alcohol at 60° F.	3 Weight in Grains of 100 Septems of the Diluted Alcohol	4 Weight in Grains of the Absolute Alcohol in 100 Septems	5 Weight in Grains of Proof Spirit at 60° F. in 100 Septems
2·39	·9956	696·92	16·66	33·83
2·45	·9955	696·85	17·07	34·67
2·51	·9954	696·78	17·49	35·52
2·57	·9953	696·71	17·91	36·36
2·62	·9952	696·64	18·25	37·07
2·68	·9951	696·57	18·67	37·91
2·74	·9950	696·50	19·08	38·76
2·79	·9949	696·43	19·43	39·46
2·85	·9948	696·36	19·85	40·31
2·91	·9947	696·29	20·26	41·15
2·97	·9946	696·22	20·68	41·99
3·02	·9945	696·15	21·02	42·70
3·08	·9944	696·08	21·44	43·54
3·14	·9943	696·01	21·85	44·39
3·20	·9942	695·94	22·27	45·23
3·26	·9941	695·87	22·69	46·67
3·32	·9940	695·86	23·10	46·92
3·37	·9939	695·73	23·45	47·62
3·43	·9938	695·66	23·86	48·45
3·49	·9937	695·59	24·28	49·30
3·55	·9936	695·52	24·69	50·14
3·61	·9935	695·45	25·11	50·99
3·67	·9934	695·38	25·52	51·83
3·73	·9933	695·31	25·94	52·67
3·78	·9932	695·24	26·28	53·37
3·84	·9931	695·17	26·69	54·21
3·90	·9930	695·10	27·11	55·06
3·96	·9929	695·03	27·52	55·90
4·02	·9928	694·96	27·94	56·74
4·08	·9927	694·89	28·35	57·58
4·14	·9926	694·82	28·77	58·42
4·20	·9925	694·75	29·18	59·26
4·27	·9924	694·68	29·66	60·24
4·33	·9923	694·61	30·08	61·08
4·39	·9922	694·54	30·49	61·92
4·45	·9921	694·47	30·90	62·76
4·51	·9920	694·40	31·32	63·60
4·57	·9919	694·33	31·73	64·44
4·64	·9918	694·26	32·21	65·42
4·70	·9917	694·19	32·63	66·26
4·76	·9916	694·12	33·04	67·10
4·82	·9915	694·05	33·45	67·94
4·88	·9914	693·98	33·87	68·78
4·94	·9913	693·91	34·28	69·62
5·01	·9912	693·84	34·76	70·60
5·07	·9911	693·77	35·17	71·43
5·13	·9910	693·70	36·09	72·25

Table—(*continued*).

1 Absolute Alcohol per cent. by weight.	2 Specific Gravity of the Diluted Alcohol at 60° F.	3 Weight in Grains of 100 Septems of the Diluted Alcohol	4 Weight in Grains of the Absolute Alcohol in 100 Septems	5 Weight in Grains of Proof Spirit at 60° F. in 100 Septems
5·20	·9909	693·63	36·48	73·25
5·26	·9908	693·56	36·43	74·09
5·32	·9907	693·49	36·89	74·93
5·39	·9906	693·42	37·38	75·90
5·45	·9905	693·35	37·79	76·74
5·51	·9904	693·28	38·20	77·58
5·58	·9903	693·21	38·08	78·56
5·64	·9902	693·14	39·09	70·39
5·70	·9901	693·07	39·50	80·23
5·77	·9900	693·00	39·99	81·21
5·83	·9899	692·93	40·40	82·04
5·89	·9898	692·86	40·81	82·88
6·96	·9897	692·79	41·29	82·86
6·02	·9896	692·72	41·70	84·69
6·09	·9895	692·65	42·18	85·67
6·15	·9894	692·58	42·59	86·50
6·22	·9893	692·51	43·07	87·48
6·29	·9892	692·44	43·55	88·45
6·35	·9891	692·37	43·97	89·29
6·42	·9890	692·30	44·45	90·27
6·49	·9889	692·23	44·93	91·24
6·55	·9888	692·16	45·34	92·07
6·62	·9887	692·09	45·82	93·05
6·69	·9886	692·02	46.30	94·02
6·75	·9885	691·95	46·71	94·86
6·82	·9884	691·88	47·19	95·83
6·89	·9883	691·81	47·67	96·80
6·95	·9882	691·74	48·08	97·64
7·02	·9881	691·67	48·56	98·61
7·09	·9880	691·60	49·03	99·58
7·16	·9879	691·53	49·51	100·56
7·23	·9878	691·46	49·99	101·53
7·30	·9877	691·39	50·47	102·50
7·37	·9876	691·32	50·95	103·47
7·43	·9875	691·25	51·36	104·31
7·50	·9874	691·18	51·84	105·28
7·57	·9873	691·11	52·32	106·25
7·64	·9872	691·04	52·80	107·22
7·71	·9871	690·97	53·27	108·19
7·78	·9870	690·96	53·75	109·16
7·85	·9869	690·83	54·23	110·14
7·92	·9868	690·76	54·71	111·11
7·99	·9867	690·69	55·19	112·08
8·06	·9866	690·62	55·66	113·05
8·13	·9865	690·55	56·04	114·02
8·20	·9864	690·48	56·62	114·99
8·27	·9863	690·41	57·10	115·96

Table—(*continued*).

1 Absolute Alcohol per cent. by weight	2 Specific Gravity of the Diluted Alcohol at 60° F.	3 Weight in Grains of 100 Septems of the Diluted Alcohol	4 Weight in Grains of the Absolute Alcohol in 100 Septems	5 Weight in Grains of Proof Spirit at 60° F. in 100 Septems
8·34	·9862	690·34	57·57	116·93
8·41	·9861	690·27	58·05	117·90
8·48	·9860	690·20	58·53	118·87
8·55	·9859	690·13	59·01	119·84
8·62	·9858	690·06	59·48	120·80
8·70	·9857	689·99	60·03	121·91
8·77	·9856	689·92	60·51	122·88
8·84	·9855	689·85	60·98	123·85
8·91	·9854	689·78	61·45	124·82
8·98	·9853	689·71	61·94	125·79
9·05	·9852	689·64	62·41	126·75
9·12	·9851	689·57	62·89	127·72
9·20	·9850	689·50	63·43	128·83
9·27	·9849	689·43	63·91	129·79
9·34	·9848	689·36	64·39	130·76
9·41	·9847	689·29	64·86	131·73
9·49	·9846	689·22	65·41	132·84
9·56	·9845	689·15	65·88	133·80
9·63	·9844	689·08	66·36	134·77
9·70	·9843	689·01	66·83	135·73
9·78	·9842	988·94	67·58	136·84
9·85	·9841	988·87	67·85	137·80
9·92	·9840	988·80	68·33	138·77
9·99	·9839	988·73	68·80	139·73
10·07	·9838	988·66	69·35	140·84

These two liquors should be contained in closely-stoppered glass bottles in a cool dark place, and they keep longest in good condition when preserved in small bottles quite full.

The wine to be tested for sugar should be so much diluted with distilled water that about 50 septems of it will contain half a grain of sugar, as the copper-test does not give accurate results when used with strong solutions of sugar.

For wines rich in surgar—*Tokay*, *Champagne*, and the *Greek* wines in general (*a*)—Mr. Griffin recommends 5 septems, diluted with water to 500; for wines of strong colour, *port*, *sherry*, *Madeira*, &c. (*b*), 10 septems, diluted to 200 septems; and for light wines containing very little sugar, both red and white (*c*), 50 septems, diluted to 100 septems.

Preparation of the Wine for the reception of the Copper-test.—A sufficient quantity of milk of lime to render the mixture distinctly alkaline is added to an accurately-measured quantity of the diluted wine, then a few drops of strong solution of subacetate of lead; the flask is then well shaken, and afterwards a small quantity of solution of alum added; the flask is then filled with water—for (*a*), to 500 septems; for (*b*), to 200 septems; and for (*c*), to 100 septems. After being well shaken the flask is set aside, in order that the precipitate may settle down. After some time the upper part of each liquor will be observed to be tolerably clear, and a portion can be filtered off through a *dry paper filter* without disturbing the precipitate. It is sufficient to filter merely enough of the liquor to fill the burette.

Many light-coloured wines require no precipitation with *lead*, *lime*, or *alum* to prepare them for action with the copper-test. It is only necessary to mix them with as much solution of carbonate of sodium as renders them alkaline to test-paper. In all cases liquors that are to be tested for sugar with the copper-test must be alkaline, because free acid destroys the copper-test.

In some cases, especially in red wines, the colouring matter and the tannin are so difficult of displacement, that *all* these additions are required to clear them sufficiently for use with the copper-test. But that is not always the case. Some wines can be cleared with the lead liquor without the use of slaked lime; others with lime without the lead solution. The clearing is often made easily and completely; at other times, a wine that is rendered quite colourless and transparent is still found to retain some ingredient, most probably tannin, which must interfere with the proper action of the copper-test. Yet with all its difficulties the copper-test is the best of all known tests for estimating sugar in wines.

Process with the Copper-test.—Introduce into a porcelain evaporating basin standing over a lamp 10 septems of the copper-test A and 10 septems of the copper-test B, and add 30 septems of distilled water; boil for a few minutes. If the blue colour of the liquor is retained, the test is in good order. Next lower the heat till the blue liquor just simmers; then, having charged the burette with the diluted wine, allow it to drop into the basin little by little, stirring continually with a glass rod. The first action of the test is to render the mixture turbid, with a greenish or reddish-brown precipitate, which does not settle readily; as the action proceeds, the precipitate becomes of a more decided red colour, and towards the end of the operation it settles down more readily, and the liquor finally becomes colourless. The oxide of copper in the basin is now of the form of a brilliant red powder. The precipitate should from time to time during the process be allowed to settle, and the basin turned a little on one side, so that the blue tint of the liquor may be seen against its sides. As soon as the last trace of blue is gone (the wine towards the last having been cautiously added drop by drop), and the bright red precipitate has settled down in a thin clear liquor, the operation is ended. With a solution of grape-sugar alone in water, these changes of colour are very clearly seen; but in some wines which, notwithstanding the addition of the clarifying reagents above mentioned, still retain organic matter, the action is disturbed, and it requires practice to arrive at uniform and correct results.

Calculation of Results :—The 10 septems of copper-test included in the two solutions A and B contain a quantity of copper, the reduction of which to the state of red oxide requires exactly *half a grain of grape-sugar*. Consequently the number of septems of diluted wine that were used show *how many septems of the diluted wine contains half a grain of sugar*. The next point to take into consideration is the state of dilution of the wine that was submitted to trial. According to the above directions, the dilutions are—

For wines under class (*a*) 1 measure to 100 measures.
" " (*b*) 1 " 20 "
" " (*c*) 1 " 2 "

Example 1.—A wine in class (*a*) reduced the copper with 29·4 septems of the diluted wine. Doubling that number, we have 58·8 septems as the equivalent of 1 grain of sugar. But as this wine was diluted from 1 to 100, the true equivalent is obtained by removing the decimal points of the number two places to the left: this gives us ·588 septems as the quantity of undiluted wine that contains 1 grain of sugar. Then to find the quantity of sugar in a centigallon, we take the proportion—

$$\cdot 588 : 1 = 100\cdot 000 : x$$
$$x = 170\cdot 0 \text{ grains.}$$

Example 2.—A wine in class (*b*) reduced the copper with 37 septems of the diluted wine. This is equal to 74 septems for 1 grain of sugar; and as this wine was diluted from 1 to 20, we have $74 \div 20 = 3\cdot 7$ as the quantity of undiluted wine that was equal to 1 grain of sugar, and then to find the quantity of sugar in a centigallon we take the proportion—

$$3\cdot 7 : 1 = 100\cdot 0 : x$$
$$x = 27\cdot 03$$

Example 3.—A wine in class (*c*) reduced the copper with 85 septems of the diluted wine. This is equal to 170 septems for

1 grain of sugar; and as the wine was diluted from 1 to 2 only, the quantity of undiluted wine equal to 1 grain of sugar is precisely the same as the number shown on the scale of the burette, namely, 85 septems; so that for wine of this degree of dilution the calculation is very simple. To find the quantity of sugar contained in a centigallon of such wine, we use this proportion—

$$85 : 1 = 100 : x$$
$$x = 1{\cdot}18 \text{ grains.}$$

Estimation of the Free Acid in Wine.—25 grains of crystallized tartaric acid are put into a 500-septem flask, which is then filled half full of distilled water and warmed to dissolve the acid. The flask is then filled nearly to the mark with distilled water and well shaken; the final adjustment is made at the temperature of 62° Fahr.

This is the Standard Acid, every septem of which is equal to ·05 grains of crystallized tartaric acid.

The test-liquor to be used in examining the acidity of wines is a solution of caustic ammonia, of such strength that 1 septem of it will exactly neutralize 1 septem of the standard acid, and will therefore indicate 0·5 grains of acid.

It is prepared as follows:—50 septems of the standard acid are put into a jar which is graduated to 250, 500, and 1,000 septems, and into a similar second jar another measure of 50 septems; the acid in both jars is then diluted to 250 septems and a few drops of an aqueous solution of logwood added, by which the liquor acquires a bright lemon-yellow colour.

Next, strong liquid ammonia is diluted with 30 or 40 times its bulk of distilled water, and the burette filled with the well-mixed liquid. One of the prepared jars of standard acid is now adjusted under the burette on a piece of white paper, and the diluted ammonia is allowed to drop slowly into it: the lemon colour of the liquid is observed to change colour, becoming first *brown*, then *pink*, and finally *crimson*.

The brown colour indicates the point of neutrality. The reaction is extremely delicate, and the change of colour very beautiful. After each addition of ammonia the mixture should be stirred; when the *brown* colour appears, all the acid is neutralized, and the burette may be read off; one drop more of ammonia will render the mixture *pink*.

The second jar is now submitted to the same trial; and if the same quantity of ammonia is not required, a second or further experiments must be made until perfectly coincident results are obtained.

Suppose that the experiments agree in showing that 35 septems of the ammonia solution are required, then in order to obtain a solution of which 50 septems shall exactly neutralize 50 septems of the standard acid, 15 burette divisions of distilled water must be added to the ammonia solution, and the experiments again made with the greatest care. In this way a solution of ammonia may be obtained, 10 septems of which exactly neutralize 10 septems of the standard acid.

Standard *nitric acid* (which is not liable to change) may be prepared by a perfectly similar operation, and it can be used to test from time to time the standard ammonia.

In the application of this process to the determination of free acid in wine the testing does not go on so smoothly and readily as testing of solutions of pure acid, because of the *colouring matter and tannin* which are present in all wines, and which in some cases deaden and confuse the action of the colour-test.

Mr. Griffin gives the following practical directions for overcoming these obstacles:—

'Put into each of two mixing jars 10 septems of the wine. If it is white wine (hock, sherry, &c.), fill up to 250 septems with distilled water. If it is red wine (port, claret, &c.), add water till the measure is 500 septems. Next add to each jar a sufficient quantity of the logwood infusion to give to the mixture a colour closely resembling that which is produced by painting paper with a colouring material called *raw sienna*. It is useful to have at hand a piece of paper painted with that colour to serve as a standard of comparison. Place one jar under the burette containing the test ammonia, and the other on a piece of white paper near it. Let the ammonia drop slowly in, shaking the jar from time to time. Gradually the colour of the mixture in the jar deepens, becoming browner, more of a reddish-brown; but the change takes place so gradually that if the second jar were away, the change of colour might scarcely be perceived. Suddenly, however, the mixture assumes a peculiar reddish-brown colour, entirely different from the *raw sienna colour* of the second jar, but which can be accurately imitated by painting a piece of paper with the colour which bears the name of *burnt sienna*. By drawing upon white paper two figures of the size of the jars, and painting one up to the mark 500 with *raw sienna* and the other with *burnt sienna*, a gauge may be provided by which it can immediately be told when the acid in the diluted wine is neutralized. The operation as just described is next performed on the mixture in the second jar, and a note taken of the quantity of test ammonia required; it should be the same as in the first experiment.'

Calculation.—Suppose that 10 septems of wine, whether diluted to 250 or to 500 septems, have required 9·1 septems of test ammonia to neutralize the acid, then 100 septems of the wine would require 91 septems of test ammonia; and as every septem of the test ammonia indicates 0·05 grains of tartaric acid, we have only this calculation to make:—

$$\begin{array}{r} \cdot91 \\ \cdot05 \\ \hline 4\cdot55 \end{array} \quad \text{or} \quad \frac{9\cdot1}{2} = 4\cdot55$$

namely, the wine contains 4·55 grains of acid in 100 septems, or 455·0 grains in the gallon.

In cases where the colouring matter and the tannin are not overpowering, larger quantities of wine may be tested, and thus the error due to mismeasurement will be lessened.

WOOL. *See* Cotton.

ZAFFRE.—Zaffre is, essentially, a combination of silica and of oxide of cobalt; that of commerce consists of roasted cobalt ore and quartz in fine powder, and consequently contains all the metallic oxides which may happen to exist in the ore. A fine sample, analysed by Normandy, contained—

Oxide of cobalt	13·5
Peroxide of iron	35·7
Alumina	3·3
Silica	43·3
Arsenic	0·8
Water and loss	3·4
	100·0

But other samples contain only from 1 to 3 per cent. of cobalt, and from 2 to 6 per cent. of nickel, also copper, and sometimes silver.

The analysis of zaffre is performed like that of the ores of cobalt and of nickel; the ore or the zaffre, previously reduced into fine powder, is treated by hydrochloric acid or by aqua regia, and the solution so obtained is filtered in order to separate the silica, which is generally a ferruginous sand; or else the pulverized mineral may be fused with about four times its weight of carbonate of potassium; the crucible containing the fused mass is placed into a large capsule, and dilute hydrochloric acid is poured upon it in small quantities at a time and gradually, as the effervescence subsides; the large capsule is for the purpose of collecting the small portions which may be projected by the effervescence.

The whole is then evaporated to dryness, the dry mass is drenched with hydrochloric acid, diluted with water, and filtered in order to separate the silica. Whichever way the solution is effected, a stream of sulphuretted hydrogen is passed through the acid solution, and the whole is left to digest for several hours in a warm place. This will precipitate the copper, silver, and arsenic which may be present in the liquor; or, if iron be present, which is almost sure to be the case, there will be also a precipitate of sulphur from the decomposition of the sulphuretted hydrogen employed, especially if aqua regia has been used. These substances are separated by filtering, and whether the solution of the mineral has been effected by hydrochloric acid or by aqua regia, some nitric acid must now be added to the filtrate, previously boiling it until all odour of sulphuretted hydrogen has disappeared, in order to peroxidize the iron which is contained in the filtrate with the oxides of cobalt and of nickel. The liquor is then neutralized by ammonia until a few flakes of peroxide of iron begin to appear, and the precipitation is completed by a solution of neutral succinate of ammonium. The persuccinate of iron thus precipitated is collected on a filter, carefully washed, ignited, and weighed as peroxide of iron.

To the liquor filtered from the persuccinate of iron a large quantity of solution of sal ammoniac is added, and it is largely diluted with well boiled water, so that it may be free from atmospheric air; and whilst still hot, the solution is put into a flask capable of being well corked, and a solution of potash being added, the flask is corked up and left at rest until the liquor has come of a fine clear red colour. More potash should be added if necessary, until this point is attained. The precipitate consists of oxide of nickel, which may be collected on a filter, dried, ignited, and weighed.

The liquor filtered from the oxide of nickel is now treated by hydrosulphuret of ammonia, which precipitates the cobalt in the state of black sulphide, which is collected on a filter, and washed with water containing a little hydro-sulphuret of ammonia. The precipitated sulphide on the filter is then scraped from it as completely as possible, and put it into a glass beaker; the filter is then burnt on the cover of a platinum crucible, the ashes are added to the mass in the glass beaker, and the whole is boiled with nitric acid until the sulphur has separated in lumps of a pure yellow colour. The liquor is then diluted with water, filtered, and the cobalt is precipitated in the state of hydrate of cobalt by a solution of potash. The precipitate is collected on a filter, washed with hot water, dried, ignited, and weighed. The hydrate of cobalt after ignition is in the state of intermediary oxide, containing three equivalents of cobalt and four equivalents of oxygen. When the exact quantity of cobalt contained in the hydrate is required, the ignited oxide should be heated in a glass bulb in a current of hydrogen gas, by which it is reduced in a state of metallic cobalt, and weighed as such. (See *Cobalt.*)

ZINC (Spelter, Spelter or Zinc Ores, Blende, Calamine). Zinc, or spelter, is obtained chiefly from two minerals, namely, *blende* or *black jack*, which is a sulphide of zinc, and *calamine*, which is a carbonate of zinc. The latter ore is the most abundant, and consequently the chief source from which the zinc or spelter of commerce is obtained.

In this country, however, *blende* is the ore generally employed.

The zinc or spelter of commerce, from whatever source produced, is never pure; it contains ordinarily about one per cent. of *iron*, of *lead*, and sometimes also some *carbon*, *copper*, *cadmium*, and *arsenic*.

The proportion of iron contained in zinc amounts sometimes to 5 or 6, or even 8 or 10 per cent.; the lowest of these proportions renders it unfit for several purposes; in that state it does not laminate well, and is almost unfit for zincing, or, as it is called, *galvanizing iron*.

These impurities are chiefly derived from the ores from which the zinc is obtained; but the iron, at least when in the large proportions above alluded to, is derived from the apparatus employed in smelting the ore by what is called the Belgian process, in which the volatilized zinc is condensed in nozzles of cast iron, into which it remains in a molten state for several hours, during which it imbibes a large quantity of iron, as above said. This process is that followed with the ores of La Vieille Montagne, and the zinc from that most extensive establishment is, therefore, always contaminated, sometimes to a great extent, by iron. In the process called the Silesian process, followed at Stolberg, near Aix-la-Chapelle, and in Silesia, the mufflers and condensers, being all made of clay, the zinc gradually dropping from the clay condensers or 'boots,' is remelted, at least at Stolberg, in clay pans, and the zinc of that establishment is on that account remarkably pure.

In order to determine the quantity of impurities contained in the metal, proceed as follows:—

Dissolve a certain weight—25 grains, for example—of the metal in a slight excess of hydrochloric acid. If a black insoluble residuum is left, it consists of carbon, which may be at once separated by filtering, washed, and weighed.

Into the acid filtered liquor a current of sulphuretted hydrogen is passed, until it smells strongly of it, and the whole is left for some time in a moderately warm place; *lead, copper, cadmium,* and *arsenic,* if any be present, are thereby precipitated in the state of sulphides of these metals, and may be separated by filtering. The filtrate which contains the zinc and iron is then to be boiled until all odour of sulphuretted hydrogen has disappeared, a little nitric acid is added to peroxidize the iron, and the whole is boiled. When the liquor, which should not contain too much acid (in which case it should be evaporated to expel the excess), has cooled, carbonate of barium in powder is added in excess, and the whole is thoroughly stirred. It is left at rest, and in the course of an hour the peroxide of iron will be entirely deposited in the state of basic carbonate of peroxide of iron, mixed with the excess of carbonate of barium employed. The precipitate is then collected on a filter, and washed.

To the filtrate dilute sulphuric acid is added, in order to precipitate the baryta which is held in solution, and after separating the sulphate of barium produced by filtering, the filtrate which now contains nothing else than the oxide of zinc, is precipitated in the state of carbonate of zinc, by pouring into it an excess of solution of carbonate of sodium; the whole is boiled, and the carbonate of zinc produced is collected on a filter, and strongly ignited, by which the carbonic acid is expelled, and the oxide of zinc left may then be weighed. 40 grains of oxide of zinc contain 32 grains of metal; or each grain of oxide of zinc contains 0·80128 grain of zinc. The impurities may be determined by the difference of weight.

Analysis of Zinc Ores.—Many ores accidentally contain zinc; in some ores—for example, in galena (sulphide of lead)—the proportion of zinc is sometimes sufficiently considerable to allow of its being separated, which in that case is accomplished simply by washing. On account of the difference of the specific gravity of the blende and the galena, the two ores may be thus most rapidly and economically separated. The principal ores of zinc are blende and calamine, and they are the only ores which are worked.

Blende is a native sulphide of zinc. It is generally in amorphous masses, of a lamellar or fibrous structure, brittle, generally of a black or greenish colour, to which circumstance it owes its name of *black jack*; frequently, however, it has a brown or ruddy tinge, in which case it is known under the name of *ruby blende.* Sometimes also, but rarely, it is yellow.

Blende is rarely met with in a pure state; in general it is contaminated by *sulphides of iron,* of *cadmium,* of *lead,* of *copper,* of *arsenic*; it may also, and does usually, contain *alumina, silica, magnesia*, and *floride of calcium.*

When blende is obtained from galena, it is important to ascertain whether it is sufficiently well prepared and duly separated from sulphide of lead, for the latter compound has a very destructive action upon the muffles in which the reduction is effected. In England, well prepared blende contains sometimes as much as 92 per cent. of sulphide of zinc, 6 per cent. of protosulphide of iron, and 2 per cent of earthy matter; its specific gravity is from 3·6 to 4·0. The usual contents of blende average from 50 to 52 per cent. of zinc.

The actual analysis of this ore is performed as follows:—

A weighed quantity—for example, 25 grains—of the ore are reduced into very fine powder and dissolved in pure nitric acid, or aqua regia, with the help of heat. The sulphides are thereby oxidized, a portion of the sulphur being converted into sulphuric acid, whilst another portion separates at first in the shape of flakes of a grey colour, but which gradually, under the influence of the boiling acid, agglomerate into lumps, which ultimately assume a pure yellow colour. The digestion in the acid should be continued until the result is obtained. The whole is then thrown upon a filter, which retains not only this undissolved sulphur, but likewise the silica which was contained in the ore. These insoluble portions are then washed and dried at a gentle heat, after which the lumps of sulphur and the silica may each be weighed separately. The sulphur, however, after weighing, should be ignited in a small counterpoised platinum crucible; if a fixed residuum remains, it consists either of the oxide of the metal with which the sulphur was combined, or of some other insoluble matter, from the matrix or *gangue.*

A current of sulphuretted hydrogen is then passed through the filtrate; if this produces a black precipitate, *lead* or *copper* is present; if yellow, it may be *arsenic* or *oxide of cadmium*; but whatever the precipitate, it must be separated by filtering, washed, and kept for further examination, should the operator wish to determine subsequently its nature and quantity.

The filtrate is now boiled until all smell of sulphuretted hydrogen has disappeared, and it is then supersaturated with ammonia. This addition of ammonia in excess will at first produce a precipitate of oxide of zinc, and of peroxide of iron, but the oxide of zinc is redissolved by the excess of ammonia employed, whilst the peroxide of iron is left on the filter in an insoluble state. But, as it retains a certain quantity of oxide of zinc, it is advisable to redissolve at once the precipitated peroxide of iron collected on the filter in a little hydrochloric acid. Ammonia is then added again in sufficient quantity exactly to neutralize the acid; and as soon as a few reddish-brown flakes of peroxide of iron begin to appear, which are not redissolved by heating the liquor, succinate of ammonium is added, so as to precipitate the whole of the peroxide of iron in the state of persuccinate of iron, which is then collected on a filter, washed, and the liquor filtered therefrom is added to that first obtained.

The whole mass of the filtrate, which is strongly ammoniacal, *colourless*, and *clear*, is then treated by hydrosulphuret of ammonia, which precipitates the zinc in the state of sulphide of zinc. This precipitate, which is bulky and white, must be allowed to settle completely before filtering; the liquor is then decanted, and the precipitate is thrown upon a filter. It is necessary to operate as first described, for otherwise the sulphide of zinc would soon block up the pores of the filtering-paper, and the filtering would then be exceedingly slow and tedious. By decanting or filtering the clear supernatant liquor, on the contrary, the filtering proceeds very rapidly, and is accomplished in a very short time. The precipitate should be washed with water to which a little hydrosulphuret of ammonia has been added, and then digested, whilst still moist, with the filter in concentrated hydrochloric acid, by which it is dissolved with evolution of sulphuretted hydrogen. The whole is then left to digest in the acid until all odour of sulphuretted hydrogen has vanished; the liquor is filtered, and the filter is washed with hot water. The oxide of zinc contained in the filtrate is then precipitated by means of carbonate of sodium. As, however, the filtrate contains a large proportion of ammoniacal salts, the carbonate of sodium must be added in sufficient quantity to decompose them, and the whole is evaporated to dryness in a Florence flask, inclined at an angle of about 45°, in order to avoid loss by spurting. More carbonate of sodium is again added, as long as a strip of turmeric paper held in the steam issuing from the flask turns brown; or as long as white fumes are observed, when a glass rod, moistened with moderately dilute hydrochloric acid, is held in the said steam or vapour.

The addition of carbonate of sodium to the liquor does not at first produce any precipitate; but by boiling, and as the ammoniacal salts in the solution are gradually decomposed, a white precipitate of carbonate of zinc makes its appearance. The dry mass left after evaporation is then treated with boiling water, filtered, washed with hot water, and the carbonate of zinc on the filter is then dried, strongly ignited in a platinum crucible, and the oxide of zinc left is then weighed.

The operator should not omit to test the liquor filtered from the carbonate of zinc precipitated by carbonate of sodium with hydrosulphuret of ammonia, for if a bulky white precipitate were then produced, it would be a proof that all the salts of ammonia have not been decomposed, and that consequently the liquor contains still some zinc. In that case the small precipitate thus produced should be separated and treated as above said.

The earths are contained in the liquor filtered from the sulphide of zinc produced by hydrosulphuret of ammonia.

Calamine.—This ore is the most abundant of the ores of zinc, and it often contains some silicate of zinc, carbonate of iron, carbonate of copper, iron-pyrites and galena. We give here the composition of the ores of calamine.

Constituents	Anhydrous silicate of New Jersey	Anhydrous silicate of la Vieille Montagne	Calamine of la Vieille Montagne	Calamine of Stolberg	Electric calamine of Busgaw
Oxide of zinc . .	7·13	63·2	5·4	2·1	66·4
Silica . . .	25·0	25·6	2·0	3·3	26·2
Water . . .	,,	1·0	0·6	0·8	7·4
Oxide of manganese	2·7	,,	,,	,,	,,
Carbonate of zinc .	,,	,,	89·0	60·0	,,
Oxide of iron . .	0·7	4·8	3·9	27·0	,,
Sulphide of iron .	,,	,,	,,	1·4	,,
Clay . . .	,,	3·4	,,	3·4	,,
Magnesia . .	,,	,,	,,	2·0	,,

The analysis of these ores is performed in the same manner as for blende, except that hydrochloric acid must be employed instead of nitric acid or aqua regia.

Commercial Carbonate of Zinc.—The carbonate of zinc of shops often contains traces only of that substance, sulphate of barium being often largely added thereto, and sometimes the so-called *carbonate of zinc* consists altogether of sulphate of *barium*, or of *carbonate of calcium*, or of *sulphate of lead*, no carbonate of zinc being present. These frauds are detected by treating the sample with hydrochloric acid, which dissolves the carbonate of zinc and of calcium, but leaves the sulphate of barium or of lead. The whole is then thrown upon a filter, and to the filtrate an excess of ammonia is first added, and then some oxalate of ammonium, which precipitates the *lime* as oxalate of calcium, whilst the zinc remains in solution. The oxalate of calcium is separated by filtering; it is washed, dried, and gently ignited, in order to convert it into carbonate of calcium, in which state it is weighed.

The ammoniacal liquor filtered from the oxalate of calcium is then treated by carbonate of sodium, in order to precipitate the zinc as carbonate of zinc, or it may be precipitated in the state of sulphide of zinc by hydrosulphuret of ammonia, the process being, in that case, the same as above described for the analysis of blende.

The portion which was insoluble in hydrochloric acid may be thus identified as sulphate of barium, or of lead; on moistening it with hydrosulphuret of ammonia it will turn black if sulphate of lead is present, otherwise it will remain white.

Commercial Sulphate of Zinc.—It is sold in colourless, right rhombic crystals, unalterable, or slightly efflorescent in the air; inodorous, with a styptic, metallic taste; soluble in 2½ times its weight of water at 60°, and in its own weight of boiling water. It is insoluble in alcohol; the specific gravity of the crystals is 1·912.

The sulphate of zinc of commerce, however, is often found in white, sometimes crystalline, sometimes amorphous and compact masses or cakes, from its having been cast into moulds after having been melted in its water of crystallization. It is generally obtained by roasting blende (sulphide of zinc), and it contains ordinarily some *magnesia*, and traces of *iron* and of *copper*. Sulphate of zinc is also obtained from the action of sulphuric acid upon the zinc of the galvanic batteries now extensively employed in electroplating.

Pure sulphate of zinc should be completely soluble in water; ammonia being added to the solution, produces at first a white precipitate, but which an excess of ammonia should completely redissolve.

The presence of *iron* is detected by dissolving a portion of the sample, and adding an excess of ammonia, which will produce reddish-brown flakes of peroxide of iron. In order to ascertain the quantity of the iron, a weighed portion of the salt should be dissolved in water, and acidified with hydrochloric acid, and an excess of solution of sal-ammoniac added; ammonia should now be carefully poured in until a few flakes of peroxide of iron begin to appear, and the precipitation of the iron is completed by means of a solution of neutral succinate of ammonia, which produces a bulky precipitate of persuccinate of iron, which may then be collected on a filter, dried, ignited, and weighed as peroxide of iron.

The liquor filtered from the peroxide of iron may then be treated by hodrosulphuret of ammonia, and the analysis proceeds exactly as described in the article on *Zinc* and *Zinc Ores*.

When only a trace of iron exists, ammonia may fail in showing it; but, in that case, the precipitate produced by hydrosulphuret of ammonia, instead of being white, will be gray or black. A trace of iron may also be detected by dissolving a portion of the sample in water, adding nitric acid, and boiling, neutralizing the acid, as nearly as possible, with ammonia, and then testing with infusion of galls, which will produce a black colour (ink) if iron be present.

If *copper* is present, a slight excess of ammonia being poured in the solution of the salt under examination will produce a beautiful blue colour; and, moreover, the solution of the salt, being first acidified with hydrochloric acid, and then treated by a stream of sulphuretted hydrogen, will produce a black precipitate. If only a trace of copper is present, the precipitate, instead of being black, is dark brown.

If *magnesia* is present, the liquor filtered from the sulphide of zinc precipitated by hydrosulphuret of ammonia, being tested with phosphate of sodium, will produce a precipitate, which is a double phosphate of magnesium and ammonium.

GLOSSARY,

WITH A CONCISE DESCRIPTION OF SOME IMPORTANT CHEMICAL PROCESSES.

Affinity. The specific attraction between different kinds of matter, which results in the formation of compounds of definite constitution, which cannot be destroyed by mechanical agencies, and are for the most part dissimilar in properties to the elements from which they are produced.

Aldehyd. The term *aldehyd* is a contraction of words which mean *deshydrogenated alcohol* (*alcohol dehydrogenatus*). The formation of acetic aldehyd by the oxidation of alcohol is expressed by the following equation :—

$$2(\underbrace{C_2H_6O}_{\text{Alcohol}}) + O_2 = 2(\underbrace{C_2\,H_4\,O}_{\text{Aldehyd}}) + 2(\underbrace{H_2O}_{\text{Water}})$$

that is, two equivalents of alcohol, by the absorption of two equivalents of oxygen, lose four equivalents of hydrogen, and are converted into two equivalents of aldehyd. Aldehyd contains therefore two equivalents of hydrogen less than alcohol. Aldehyd is a colourless fluid, possessing a suffocating ethereal odour.

Amorphous (from ά, 'not,' μορφὴ, 'form'). This term is applied to a substance which has an irregular form : for example, a lump of chalk.

Aqua Regia. A mixture of hydrochloric and nitric acids; so called from its property of dissolving gold, which was named by the alchemists the *king of the metals.*

Base. This term is the correlative of *acid.* It is generally applied to alkalies, earthy, and salifiable metallic oxides, which are looked upon as the *bases* of the compounds (salts) resulting from their union with acids, &c. Its signification varies, however, to a certain extent, according to the view taken of the constitution of salts.

Black Flux is made by mixing thoroughly two parts of pulverized *tartar* (*bitartrate of potassium*), and deflagrating the mixture in successive portions in an iron ladle or in a crucible.

Blow-pipe. The name of a useful little instrument for submitting small substances to a high temperature. The most simple form of blow-pipe is a conical tube of japanned tin-plate or brass, about seven inches long, bent nearly at a right angle about two inches from the narrow end; but, as during the operation of blowing from the mouth aqueous vapour condenses, and is driven through the jet with the stream of air, various contrivances have been devised for condensing the water. Dr. Black's blow-pipe, the tube of which is conical, is shown in fig. 27, and Plattner's in fig. 28. The principal point to be attended to in the construction of the blow-pipe is the jet, of which there should be two, the calibre of the one being rather larger than that of the other. The aperture should be perfectly round and smooth, and the channel leading to it conical; and it should be made of platinum, as being easier kept clean. In using the blow-pipe, the air is supplied from the mouth, and not from the lungs; and during the blast the communication between these organs is closed,

Fig. 7.

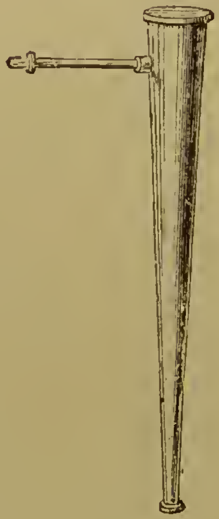
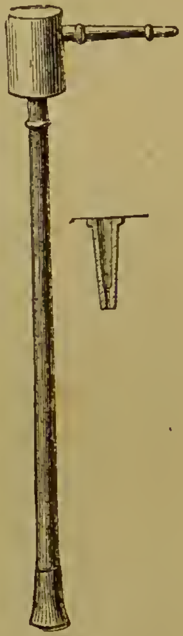


Fig. 28.



respiration being carried on through the nostrils. The description of the method of blowing through the pipe is far more difficult than its acquisition. It is necessary, in the first place, to acquire the habit of keeping the cheeks distended with air whilst respiration goes on in an unimpeded manner through the nose, and to open and close the communication between the mouth and the lungs, and between the lungs and the air, at pleasure. When this habit is gained, no difficulty is experienced in keeping up a long and continuous stream of air without fatigue.

The fuel for supplying the flame for the blow-pipe may be either that of a candle with a thick wick, or olive or refined rape-oil.

FIG. 29.

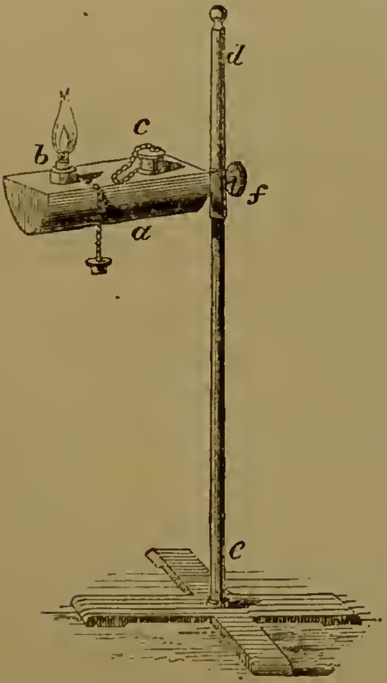
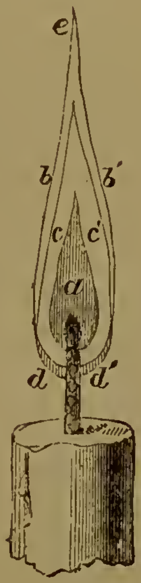


FIG. 30.



BERZELIUS's lamp is shown in fig. 29. The vessel containing the oil, *a*, is adapted to a vertical support, *e d*; the oil-vessel is furnished with two apertures, *c* and *b*, each of which may be closed by a cap; the fuel is supplied through *c*, and the wick is introduced through the aperture *b*. If a candle be employed it should be snuffed rather short, and the wick turned on one side towards the object, so that part of it may lie horizontally. The stream of air from the blow-pipe must be blown along the horizontal part, as near as possible without striking the wick.

To understand the method of managing the blow-pipe requires a knowledge of the properties of the different parts of a flame, which may best be studied on that of a steady-burning candle. Fig. 30 represents such a flame, which will be found, on examination, to consist of four distinct parts. The base, *d d*, is bright blue; it is here that oxygen enters the flame; the blue colour, which is produced by the thorough combustion of the carbon of the fuel, disappears as the flame elongates, giving place to a thin, scarcely visible coating, *b b′*. Chemical action is here most intense, and this exterior mantle is the hottest part of the flame. In the very centre of the flame, surrounding the wick, is a dark conical spot, *a*; this is the magazine, as it were, of the inflammable gases derived from the decomposition of the tallow; it is shut out from all communication with oxygen, and the combustible gases consequently remain unburned. Surrounding this dark portion is an intensely luminous envelope, *c c′*. It is here that the inflammable compounds of carbon and hydrogen are decomposed; the hydrogen burns into water; but the carbon, not meeting with a sufficient supply of oxygen to effect its oxidation, separates in a state of intense ignition. A few simple experiments will serve to elucidate the above description.

The hollow structure of the flame is proved by bringing down upon it a piece of thin glass or wire gauze, and viewing the section of the flame from above. That this hollow is filled with inflammable gases is demonstrated by carefully introducing into its centre a piece of thin glass tube one-eighth of an inch in diameter and six or eight inches long: the gases will escape through this tube, and may be inflamed at its exterior aperture. That the luminous part of the flame consists of intensely ignited charcoal is shown by introducing into it a cold body, such as a plate, which will become blackened from the deposition of carbonaceous matter. That the blue colour at the base of the flame is occasioned by the combustion of some form of carbon, is proved by holding close to it a glass rod, from the end of which a drop of lime-water is suspended — the clear liquid speedily becomes milky, owing to the formation of carbonate of calcium; and, lastly, that the hydrogen of the fuel is being converted into water at the exterior envelope is rendered evident by holding near it a large bright metallic surface, such as a polished snuffer, which speedily becomes bedewed with moisture. Of these four parts of the flame *two* are principally concerned in blow-pipe operations—the blue part and the luminous part; and these two have totally different, and indeed opposite functions. From the first is produced the *oxidizing* flame, and from the second the *reducing* flame. The *oxidizing flame* may be considered as the blue oval base converted into a cone. To produce it, the nozzle of the blow-pipe is introduced about one-tenth of an inch within the flame, immediately above the wick, and a gentle and uniform current of air kept up from the mouth. The heat is greatest at the extremity of this flame; but to obtain the greatest oxidizing power, the subject of experiment should be kept as far from the apex of the flame as is consistent with a sufficiently elevated temperature. A too powerful blast must be avoided, as tending to cool the flame and to injure the process of oxidation: the aperture in the nozzle of the blow-pipe must not be too small.

Fig. 31 shows the form which the flame should assume when oxidizing effects are desired; the blue dart, *a*, *b*, is the lower blue exterior part of the flame in its natural state, now concentrated in the interior. The *reducing flame* is more difficult to obtain; the jet of the blow-pipe must not be introduced into the flame, but kept just on its edge; and the stream of air, thrown higher over the wick than in the oxidizing flame, the whole of the luminous portion thus becomes deflected, and appears as a long narrow cylinder surrounded by a feeble luminous mantle. It is in the luminous portion, consisting of partially consumed combustible matter, strongly disposed to combine with oxygen, that reductions are effected, and the assay must be entirely surrounded with it. Fig. 32 may serve to convey some idea of the general ap-

FIG. 31.

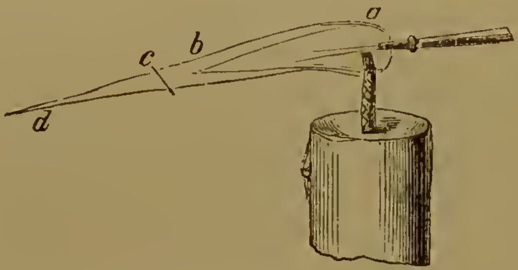
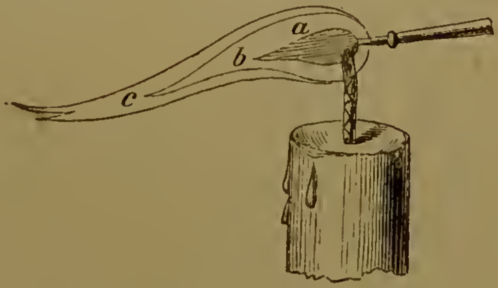


FIG. 32.



pearance of the reducing flame. If a lamp or candle be used as fuel, attention must be paid to the condition of the wick, which must be of moderate length, and very evenly and smoothly cut. The orifice of the jet of the blow-pipe should be smaller than when oxidation is the object, and the blast must be moderately strong and uninterrupted. When the subject of the experiment has to be *reduced,* charcoal is employed as the support; but when the object is to ascertain what coloured bead it produces when fused with borax or microcosmic salt, a platinum wire, curved at one end, may be advantageously employed. It should be about two inches long, and attached to a small glass tube as a handle. In using these wires the hook is moistened in the mouth and then dipped into the pounded fused borax which is melted in the flame into a clear bead; when cool it is again moistened, a minute quantity of the substance to be examined caused to adhere to it, and both fused together.

It is frequently required to heat the substance with nitrate or bisulphate of potassium; this is done in the small platinum spoon (fig. 33), of which it is convenient to have two sizes—one about nine-sixteenths of an inch in diameter, for melting substances with bisulphate of potassium; and the other about three-eighths of an inch in diameter, for fusing substances with nitre. Stains on these spoons are best removed by rubbing them with charcoal powder. In order to try the fusibility of a specimen, it is held in the flame by means of the platinum forceps (fig. 34). The following simple method of preparing small thin clay basins, for roasting ores and for the reduction of lead and tin oxides contained in calcined and uncalcined minerals, &c., is given by Plattner. A fine proof-clay is kneaded into a stiff paste with water; and, having rubbed the surface of the boxwood press (fig. 35) with oil, a slip of paper three inches in length and one-fourth of an inch in breadth is placed on the middle of the concavity of the press, which is seven-eighths of an inch wide and five-sixteenths of an inch deep, and upon this a small clay-ball about half an inch in diameter;

Fig. 33.

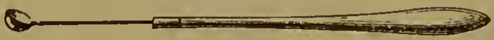
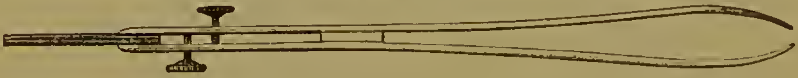


Fig. 34.



the upper surface of the press is then stamped horizontally on the clay mass as far as is required. This being done, the superfluous clay will have exuded, and the handle or upper part of the apparatus can be removed easily by careful turning; with a small knife the clay which is driven out may be cut away, and it can then be seen whether the basin is sufficiently thin and uniform; if so, the slip of paper is gently pulled and the dish extracted. After a few hours' drying, the paper detaches itself from the little clay dish, which is then heated to redness in a platinum crucible. These basins should not exceed one thirty-second of an inch in thickness, and the proper consistence of the clay is soon ascertained; if the edges of two of these little vessels be ground with a file, one may serve as a cover to the other.

FIG. 35.

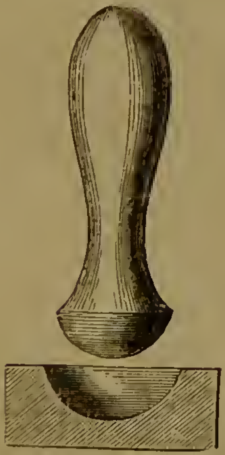
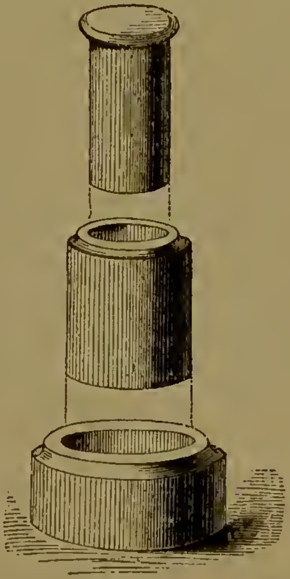


FIG. 36.



The steel mortar (fig. 36) is an apparatus of great use to the blow-pipe and mineral analyst. It consists of three separate parts. The lower portion is a shallow dish of steel into which a massive hollow hemispherical cylinder also of steel is accurately fitted by grinding; the upper portion is a solid cylinder. When a mineral has to be crushed, it is introduced into the bed of the mortar; the solid cylinder is then replaced and struck forcibly several times with a wooden mallet, by which it is reduced to a coarse powder, and may afterwards be brought to an impalpable powder by grinding it in an agate mortar.

BULK. See *Volume*.

CELLULOSE AND LIGNINE. Cellulose, or *cellular tissue*, is common to the cellular structure of all vegetables. Its centesimal composition is—

Carbon	44·44
Hydrogen	6·18
Oxygen	49·38
	100·00

In young plants the cells are formed in the midst of the sap, which circulates in their stalks, and each cell is successively developed in attaching itself to those previously formed. The forms are modified in this process: sometimes they are round, and manifest a certain regularity of arrangement and form, as in the pith of elder (fig. 37). In this case they consist of *cellular tissue*, pro-

FIG. 37.

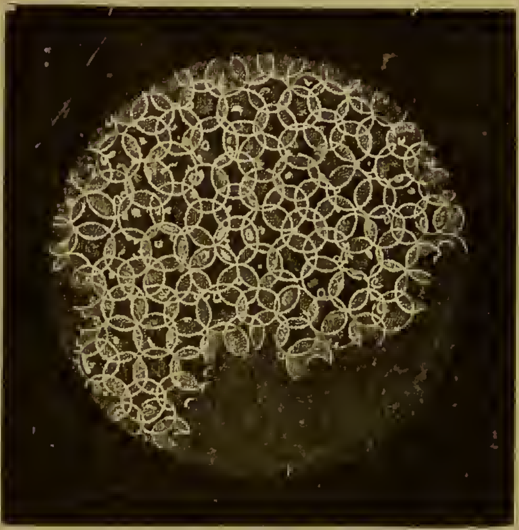


FIG. 38.

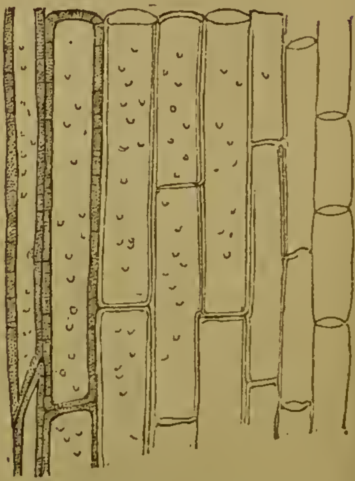


FIG. 39.

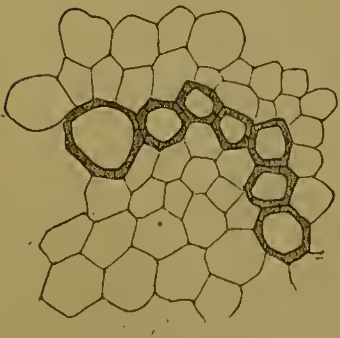
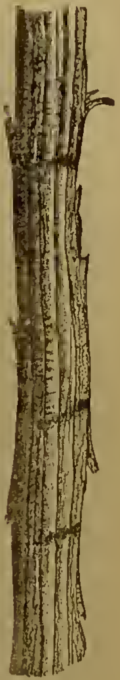


FIG. 40.

perly so called. Sometimes they affect the form of oblong vessels connected at the ends, as is shown in the longitudinal and transverse sections of the stalk of asparagus (figs. 38 and 39), and in fibres of hemp or flax (fig. 40), or of cotton, (fig. 41). In such cases they are called *vascular tissue.*

FIG. 41.



As the plant advances in age the coating of lignine encrusting the inner surfaces of these vessels becomes thicker and thicker, leaving less and less open space within for the circulation of the sap. This combination constitutes what is familiarly known as *wood.*

Cellulose is almost pure in the hairy matter of the cotton-plant, in hemp, in flax, and in artificial substances derived from these, such as paper, and the rags from which it is made. It is all but absolutely pure in the Swedish filtering-papers. To obtain it chemically pure it is only necessary to treat these bodies successively with water, alcohol, ether, the weak acids, and dilute alkalies.

Pure cellulose is white, solid, translucent, insoluble in water, alcohol, ether, and the oils fixed and volatile. Its composition is expressed by the formula $C_6 H_{10} O_5$.

The dilute acids and alkalies have but little action upon it. Its resistance to these reagents varies with its age, the fresh and recently formed being more easily affected than the old and more cohesive. Concentrated sulphuric and phosphoric acids produce remarkable effects upon it, converting it first into *dextrine* and then into *glucose.* A mixture of sulphuric and fuming nitric acids converts it into *pyroxyline* or *gun-cotton.* At a boiling heat nitric acid dissolves it, oxalic acid being formed. Acetic acid is without action on it, but it dissolves completely in *an ammoniacal solution of oxide of copper.*

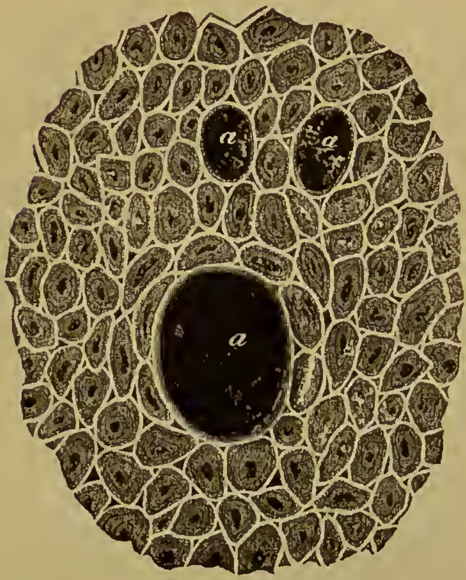
When cellulose has been disintegrated by sulphuric acid it is rendered blue by a solution of iodine—a property which indicates its close relation to starch, with which it is isomeric. This reaction serves to distinguish cellulose from certain nitrogenised membranes, which do not possess this property.

Lignine, which lines and encrusts the woody cells, is produced from the organic compounds dissolved in the sap. Its structure is illustrated in fig. 42, which is a microscopic view of the transverse section of oak. The black parts show the canals which remain open for the circulation of the sap within the lignine, some of which, such as *a, a, a,* being much larger than others, are the chief conduits of that liquid.

The structure of the trunk of a tree being produced by the annual formation of matter collecting in a succession of cylindrical shells, one outside another, it follows that the central part is the oldest, and the exterior part, immediately within the bark, the youngest and most recent. As the incrustation of lignine augments with age, it follows that the central part must always be more dense than the external. The latter, therefore, having more open spaces for the circulation of the sap, is denominated *sap-wood*, the central and more dense part being called the heart.

The lignine being friable, can be separated from the cellulose by bruising and sifting. It contains a greater proportion of hydrogen than the cellulose, and gives more heat in combustion. For the same reason the hard woods, which contain a greater proportion of lignine, have a greater calorific power. Lignine is blackened by sulphuric acid and soluble in chlorine; by these properties it is distinguished from cellulose.

FIG. 42.



CHOLESTERINE. A fatty substance extracted from the brain, nerves, gall, and liver. It exists also in blood and in the yolk of eggs. The biliary calculi found in the gall-bladder often consist of almost pure cholesterine. The calculi, treated by boiling alcohol and decolorized by animal charcoal, yield pure cholesterine. That which distinguishes cholesterine from all other fatty substances is that it cannot be saponified, and that its point of fusion is very high. The composition of cholesterine is expressed by the formula ($C_{26}H_{44}O$); it is a white, tasteless, and inodorous substance, insoluble in water, but dissolving very readily in boiling alcohol, from which it separates on cooling in beautiful crystalline nacreous laminæ, soft to the touch, and melting at about 278° F.

CONCENTRATION. The operation by means of which the solution of a substance is reduced to a smaller bulk. This is generally done by boiling off a suitable portion of the liquid. (See *Heat, Sources of.*)

CONSTITUENTS. Names of the individual substances of which compounds consists. Thus the constituents of oil of vitriol

(H_2SO_4) are hydrogen, sulphur, and oxygen; the constituents of sulphate of potassium (K_2SO_4) are potassium, sulphur, and oxygen.

CRUCIBLES. By this name are designated those vessels in which substances are subjected to high temperatures. They vary considerably in material as well as in shape. Those most commonly employed in the laboratory are the following:—

a) *The Hessian Crucible,* to which preference is almost always given where earthen vessels are required. They are triangular in shape, and will resist a high temperature, as well as the action of fluxes.

b) *The Cornish Crucible.* These are generally round, and are provided with covers. In power of resisting high temperatures and the action of fluxes they are nearly equal to the Hessian, from which they are distinguished by their colour being white.

c) *The Blue-pot* or *Black-lead Crucible.* These vessels are made of a mixture of black-lead and clay, and are generally of a large size, being used principally in the arts. They bear a very high temperature, and withstand the action of fluxes.

Crucibles made of *Berlin ware, biscuit porcelain,* and *Meisser ware,* are also much used. They are made very thin, and will stand a high temperature. The most convenient shapes are shown in figs. 43 and 44. Besides these a crucible and cover of *platinum* is indispensable to the analytical chemist. This valuable vessel should be used with care; it should never be exposed unprotected to the fuel of a furnace; and when a very high temperature is required, it should be inserted into a Cornish crucible, the intervening space being filled up with magnesia. A pure silver crucible may in some cases be substituted for one of platinum; but it must be borne in mind that silver is far more fusible than platinum.

FIG. 43.

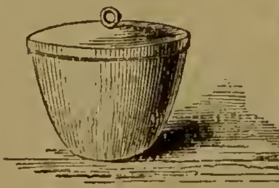
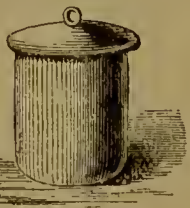


FIG. 44.



Fusible metals, or compounds of metals likely to be reduced, must never be heated in vessels of silver or platinum, as the alloy formed greatly injures them. All compounds of *lead* must be carefully avoided.

CRYSTALLIZATION. Most bodies, whether simple or compound, in passing from the fluid to the solid state, manifest the peculiarity of structure which is expressed by the term *crystalline,* and great numbers are found, especially in the mineral kingdom, naturally in this condition. When a body in this state is broken, its surface of fracture will present the appearance of a multitude of pointed asperities which will at first seem to be irregular, but when submitted to the microscope will be found to have a certain uniform geometrical structure.

When a crystalline body is split, it is found that its division is much more easily effected in some directions than in others. Such directions are called *planes of cleavage*, and are in fact parallel to the faces of the component crystals.

The relative direction of the planes of cleavage supply one of the means of determining the forms of the crystals.

The exposition of the properties of crystals forms the part of physical science called *crystallography*, and the processes by which bodies are reduced to the crystallized state are called *crystallization.*

Crystallization may be produced artificially by four methods.

1. *By fusion.* If a body be fused and then permitted to cool by slow degrees until it be solidified, it will crystallize.

Ex.: If sulphur be melted and left to cool, a solid crust will be formed upon it. If this be broken and the sulphur which is still liquid be poured off, a beautiful wall of crystals will be seen attached to the sides of the vessel.

2. *By volatilization.* Certain solids, when their temperature is raised to a point below their point of fusion, are volatilized. Their vapour thus produced, being condensed, forms crystals.

Ex.: If arsenic be raised to 365° in a stoneware retort connected with a condenser, it will be volatilized without fusion, and its vapour will be condensed in the form of crystals.

3. *By solution in the humid way.* A solid being dissolved in a liquid and the solution evaporated, crystals will be deposited when the proportion of the solvent becomes insufficient to hold all the solid in solution.

Ex.: If a solution of sugar be slowly evaporated without agitation, fine crystals of sugar-candy will be deposited.

4. *By solution in the dry way.* This process consists in the use of solvents which have high points of fusion, and which being slowly evaporated in the incandescent state deposit crystals of the body they hold in solution. EBELMAN, to whom this method is due, obtained crystals of certain minerals never found crystallized in their native state.

Ex.: Fused boracic acid dissolves most of the metallic oxides. If a mixture of alumina and magnesia in the proportion in which they are found in the mineral called *spinelle* be dissolved in boracic acid fused in a porcelain oven, artificial spinelle will be produced in a crystallized state by evaporating the boracic acid.

Crystalline Systems. Although they are infinitely various, crystalline forms have been reduced to a very limited number of classes. Some forms are mere modifications of others of a more simple nature. Others are produced by the combination of the more simple forms.

Centre. Within every crystal there is a certain point which divides into equal parts every line passing through it and terminated in the faces or edges of the crystal. This point is called the *centre* of the crystal, from its analogy to the centre of a circle, which divides the diameters into equal parts.

Diameters. Lines passing through the centre and terminated in the crystal are called *diameters.*

Axes. Diameters so placed that a plane passing through them will divide the crystal into equal and similar solids, are called *axes.* The crystal is therefore disposed symmetrically around each of its axes.

These axes are distinguished by very important optical properties, which often serve as a convenient method of determining their direction.

All the varietes of crystalline forms have been reduced to six classes called *crystalline systems,* which are severally characterised by the number, relative position, and relative length of the axes.

1. *The regular system* has three equal axes, each of which is at right angles to the plane of the other two.

FIG. 45.

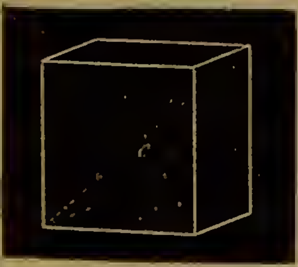
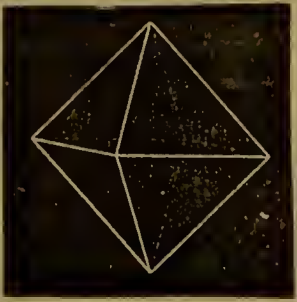


FIG. 46.



This system includes the *cubes* or *regular hexahedron* (fig. 45), which has several systems of axes. Thus lines joining the centres of the square faces, and lines joining the opposite angles, are axes.

It also includes the *regular octohedron* (fig. 46), the axes of which are lines joining the opposite angles. Also the *regular rhombic dodecahedron* (fig. 47), the *regular tetrahedron,* whose faces are four equilateral triangles (fig. 48), and various other forms derived from these by modification or combination.

2. *The square prismatic system* takes its name from the square

right prism, the height of which is greater or less than the edge of its base. In this system there are three axes, each of which is at right angles to the plane of the other two. Two are equal, but the third is greater or less than these.

FIG. 47.

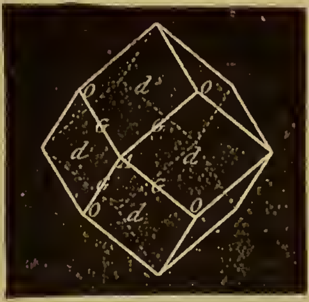
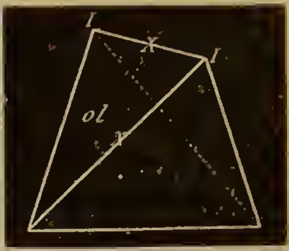


FIG. 48.



This system includes, besides the *rectangular square prism*, the *octohedron* with a square base (fig. 49), the axes being the two diagonals of the base and the line *c c*.

FIG. 49.

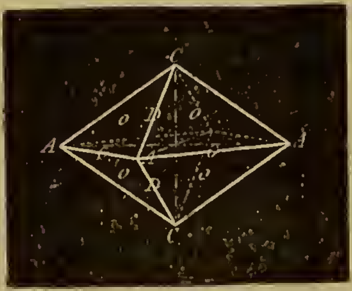
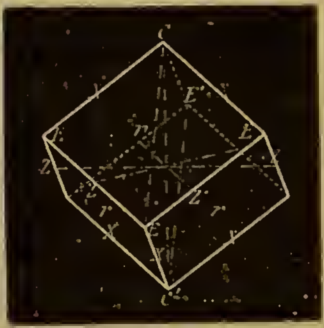


FIG. 50.



3. *The rhombohedral system* has four axes, of which three are equal, in a common plane, and intersect at angles of 60°, the fourth being at right angles to this plane.

This system takes its name from the *rhombohedron* (fig. 50), which is one of its principal forms. The principal axis *cc′* joins two opposite angles, while the other three or secondary axes join the middle points of the opposite edges.

This system also includes the *regular dodecahedron* (fig. 51), the faces of which are 12 equal isosceles triangles standing on a common hexagonal base, the three diagonals of which are the secondary axes. It also includes the *right hexagonal prism* (fig. 52), and the *dodecahedron* (fig. 53), with scalene triangular faces.

4. *The right prismatic system* has three unequal axes, each of which is at right angles to the plane of the other two.

This system takes its name from the *right prism* with a rectangular base, which is one of its forms. The principal axis is the axis of the prism and the lines joining the centres of the opposite lateral faces.

FIG. 51.

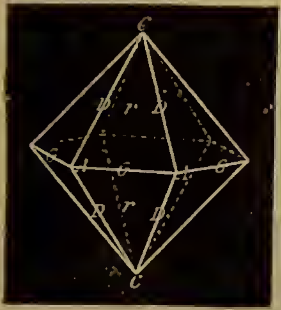


FIG. 52.

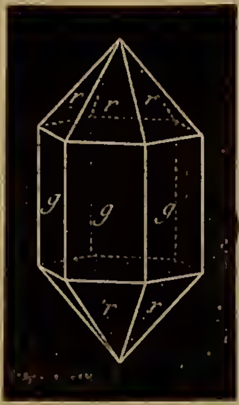
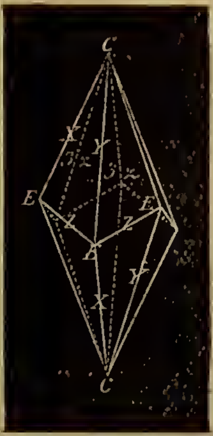


FIG. 53.



Another form of this system is the *right octohedron* with a rhombic base (fig. 54), consisting of two right triangular pyramids having a common rhomboic base. The axis of the pyramids is the principal, and the diagonals of the base the secondary axes.

FIG. 54.

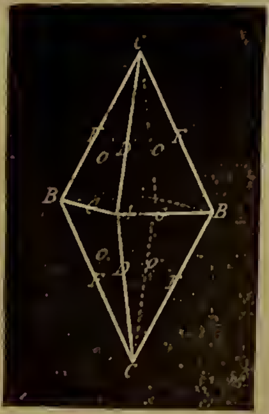
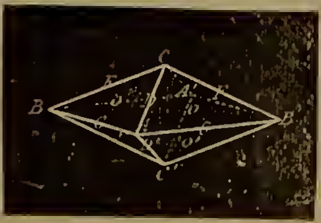


FIG. 55.



5. *The oblique prismatic system* has three unequal axes, two of which are oblique to each other, the third being perpendicular to their plane.

This system takes its name from the *oblique rectangular prism*, whose base is a rectangle with unequal sides, its axis being inclined to the base. The axis of the prism is the principal, and the lines joining the centres of its opposite lateral faces the secondary axes.

The octohedron (fig. 55), consisting of two scalene triangular pyramids with a rectangle as a common base, belongs to this system.

6. *The doubly oblique prismatic system* has three unequal axes, each of which is inclined to the plane of the other two.

This system includes the *oblique prism* with an oblique parallelogram as a base: the octohedron consists of two scalene triangular pyramids with an oblique parallelogram as their common base.

The following are examples of the crystalline forms of the several systems:—

1. *Regular system.* Most of the metals, diamond, salt, alum, garnet, fluor-spar, galena.
2. *Square prismatic.* Zircon, tinstone, apophyllite, ferrocyanide of potassium.
3. *Rhombohedral.* Ice, calcareous spar, nitrate of soda, rock crystal, arsenic, antimony.
4. *Right prismatic.* Sulphur (at low temperature), nitre, iodine, sulphates of potassium and barium.
5. *Oblique prismatic.* Sulphur (by fusion), realgar, sulphate, carbonate, and phosphate of sodium, borax, green vitriol.
6. *Doubly oblique prismatic.* Sulphate of copper, nitrate of bismuth, quadroxalate of potassium.

When the same body is capable of crystallizing in different systems, under different conditions, it is said to be *dimorphous.* Sulphur is an example of this.

When two different bodies crystallize according to the same system, they are said to be *isomorphous.*

Cube. A crystal which has six square and equal surfaces. Dice are cubes.

Decantation. When a liquid contains solid particles heavier than itself, these ordinarily will gradually subside to the bottom, the whole be left at rest. The supernatant liquor may then be separated by carefully pouring it, or siphoning it off, and this is called *decanting.* Decantation, therefore, answers the same purpose as filtration. (See *Filtration.*)

Decrepitate. A substance is said to decrepitate when, on being exposed to heat, it crackles and flies off. A familiar illustration is offered by throwing common salt into the fire, or by heating it on a metallic plate or in a crucible.

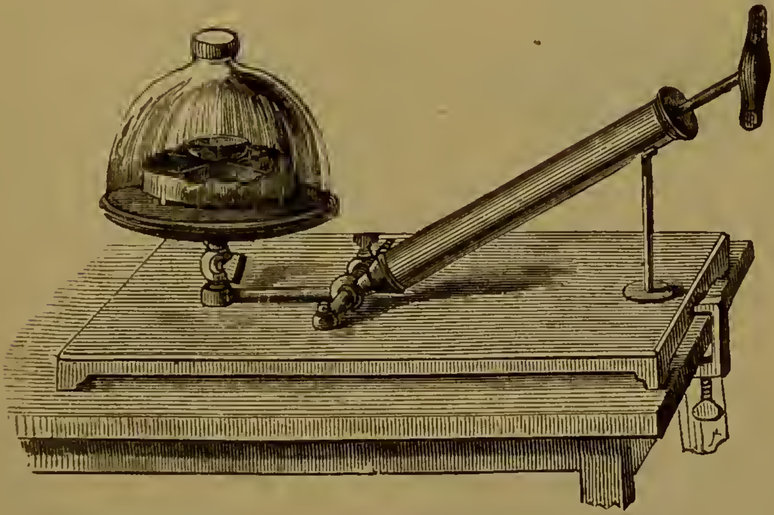
Deliquescent (from *deliquere,* to melt, to become liquid), is said of a solid substance which gradually falls into a liquid by absorbing moisture from the atmosphere.

Desiccation. The operation of drying. Bodies differ very much in their relative powers of absorbing and retaining water;

but it is necessary to distinguish carefully between the water which a substance may contain in accidental admixture, and that which belongs to it *essentially*, being a part of its constitution. In the preliminary operation of drying, this latter water must not be interfered with.

The preparation of *efflorescent* and *deliquescent* crystals in a state fit for analysis is rather difficult. It is obviously inadmissible to expose them to the air; they must therefore be deprived of their water of admixture by pressing them, in a finely divided state, between folds of bibulous paper, until there are no longer signs of moisture on the latter. There are many substances, particularly such as are of an organic nature, which though they do not lose their water of admixture in a dry atmosphere at common temperatures, cannot nevertheless be exposed to the temperature of 212° F. without undergoing decomposition. The desiccation of such substances may be effected by placing them in a watch-glass, over a shallow basin containing strong oil of vitriol, underneath the receiver of an air-pump, and exhausting the air. The arrangement is shown in fig. 56; or, more simply and without the employment of the air-pump, by suspending the substances in a watch glass, *d* (fig. 57), over the surface of oil of vitriol contained in a beaker, the edge of which is ground so that it may be closed accurately by the ground-glass plate, *b*, in the centre of which is inserted the cork, *c*, from which the support containing the watch-glass hangs.

FIG. 56.



Substances which will bear the heat of boiling water may be dried in the water-oven, B (fig. 59).

It consists of a copper box about six inches square, provided with a water-tight jacket, the edges being soldered with brass. It is furnished with a door, in which is cut a small ventilating aperture, which can be opened or closed at pleasure by means of a small nut. One of the chimneys on the top of the box communicates with the jacket; through this the charge of water is given to the apparatus; the other communicates with the interior chamber, in which the substance to be dried is placed in a watch-glass, the edge of which is ground so that it may be covered air-tight with another similar watch-glass, held tightly upon it during the operation of weighing by a clasp, as shown in fig. 60. If a higher temperature than boiling water be required, the oven may be filled with a fixed oil, such as olive-oil, the temperature being regulated by thermometer. The water-bath A (fig. 58), is an apparatus indispensable in the chemical laboratory. It serves to complete the desiccation of large quantities of liquid at an unvarying temperature; it is likewise exceedingly useful for digestions, concentrations, and numerous other operations in which the heat of boiling water is required.

FIG. 57.

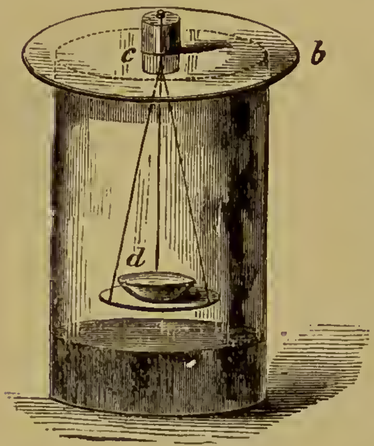


FIG. 58.

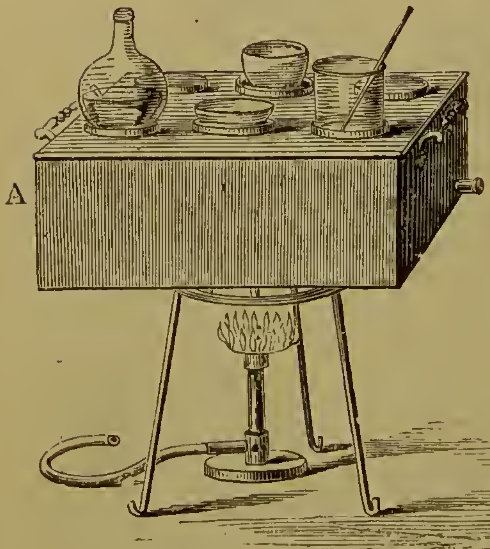


FIG. 59.

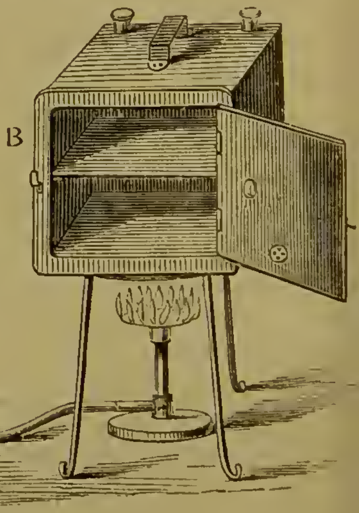


Fig. 61 represents a very useful contrivance for drying substances at any required temperature. It consists of a cylindrical box of copper, provided with a jacket or double casing, and a false bottom pierced with holes for the more equable diffusion of air through the interior. It is also provided with a tall chimney, to determine a strong current of air through the chamber, and a thermometer for regulating the temperature. The substances to be dried are placed in dishes or watch-glasses, on a trellis-work of copper or iron, placed about an inch above the false bottom. By carefully adjusting the flame of the oil or gas lamp placed underneath, it is easy to maintain, for any length of time, a perfectly uniform heat.

FIG. 60.

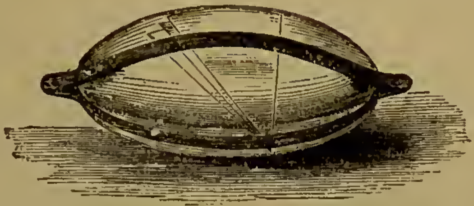
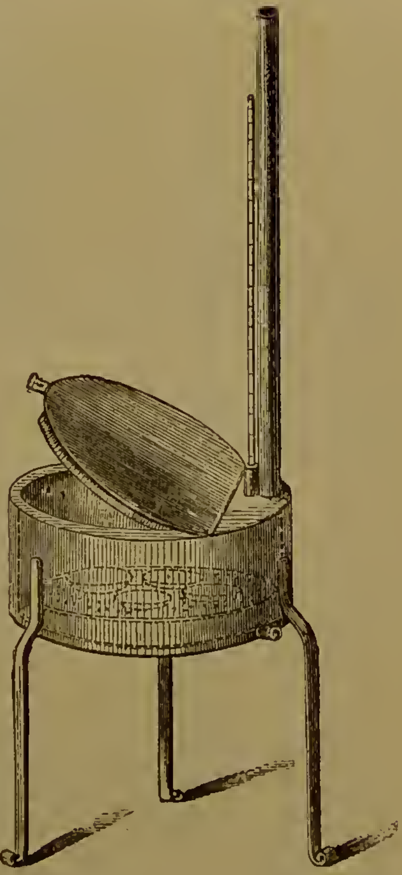
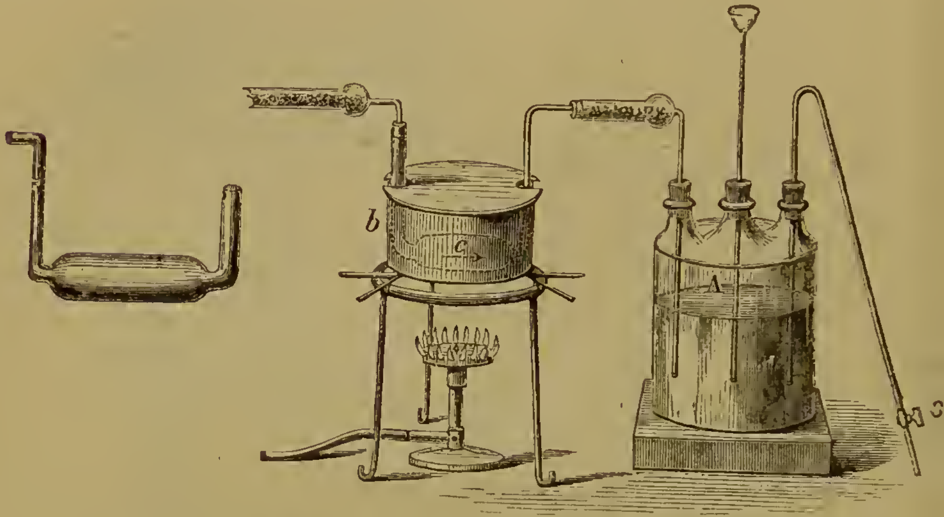


FIG. 61.



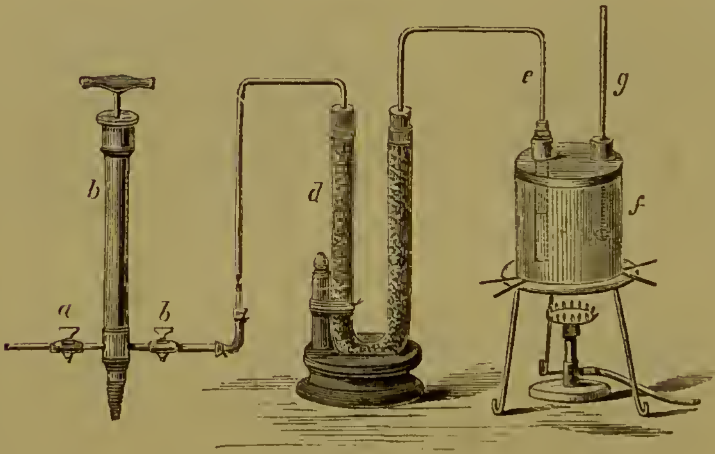
In fig. 62 is shown an arrangement for drying substances in a current of dry air, produced by the efflux of water. The substance is introduced into a small bent tube, *c*, which has been weighed. The body of this tube is plunged into the copper water-bath, *b*, charged with a saturated solution of common salt; it is kept in its place by a cover furnished with two apertures, to receive the arms of the drying-tube; the wider arm is united by means of a bent tube, and a caoutchouc connector, with a tube containing fragments of chloride of calcium; and the narrower arm is connected with another chloride of calcium tube bent at right angles, so as to pass through the cork of the *aspirator*, A, and reach down nearly to its bottom. This aspirator is filled with water, and on exhausting the siphon it flows out in a small stream, which may be regulated by the cock, *s*, its place being supplied by the air drawn through *c*, and which becomes dried during its passage through the chloride of calcium. The bath is charged with water, a saturated solution of common salt, or of chloride of calcium, according to the degree of heat required.

FIG. 62.



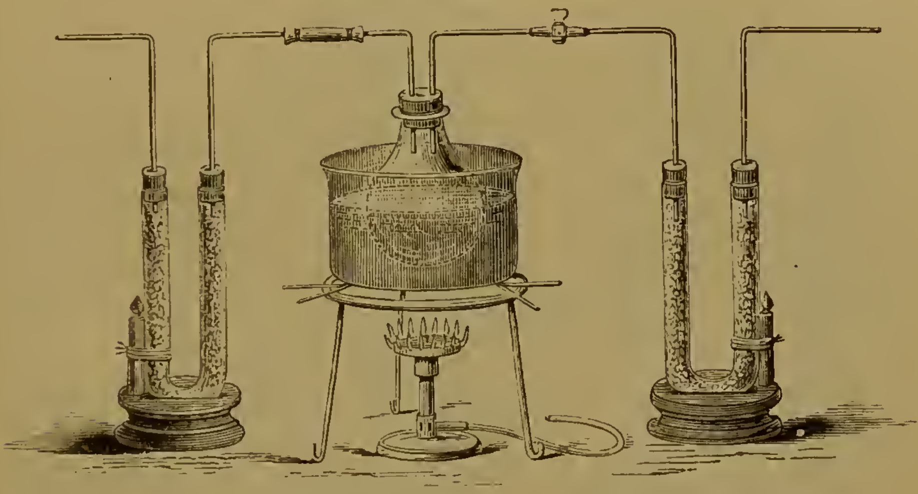
In fig. 63 is shown an arrangement for drying, at any required temperature, *in vacuo*. The substance is placed in a glass tube, *e*, which passes through a copper collar into the air-bath, *f*.

FIG. 63.



This tube is closed air-tight with a good cork, into which is inserted a bent glass tube, establishing a communication with the chloride of calcium tube, *d*, and finally with the exhausting syringe, *b*. By raising and depressing the piston a few times a tolerable vacuum is produced in the tube; and by means of the stopcocks, *a* and *c*, air may be admitted from time to time, which becomes deprived of all moisture previous to entering the tube containing the substances, by passing over the chloride of calcium tube, *d*. In cases in which it is desirable to exclude atmospheric air, the substance to be dried may be placed in a flask immersed in an oil-bath provided with a thermometer, and a current of hydrogen or carbonic acid drawn from a reservoir through the left-hand chloride of calcium tube (fig. 64), by means of an exhausting syringe connected with the chloride of calcium tube on the left hand. The air in the flask is rarefied by a few strokes of the piston; the cock of the syringe is then closed, and that communicating with the gas reservoir opened, upon which a current of dry gas enters the flask. This operation is repeated two or three times, till the apparatus is completely filled with dry gas. The oil-bath is now raised to the requisite temperature, the flask is again exhausted, fresh dry gas being again admitted. In about one hour the desiccation will be complete.

FIG. 64.



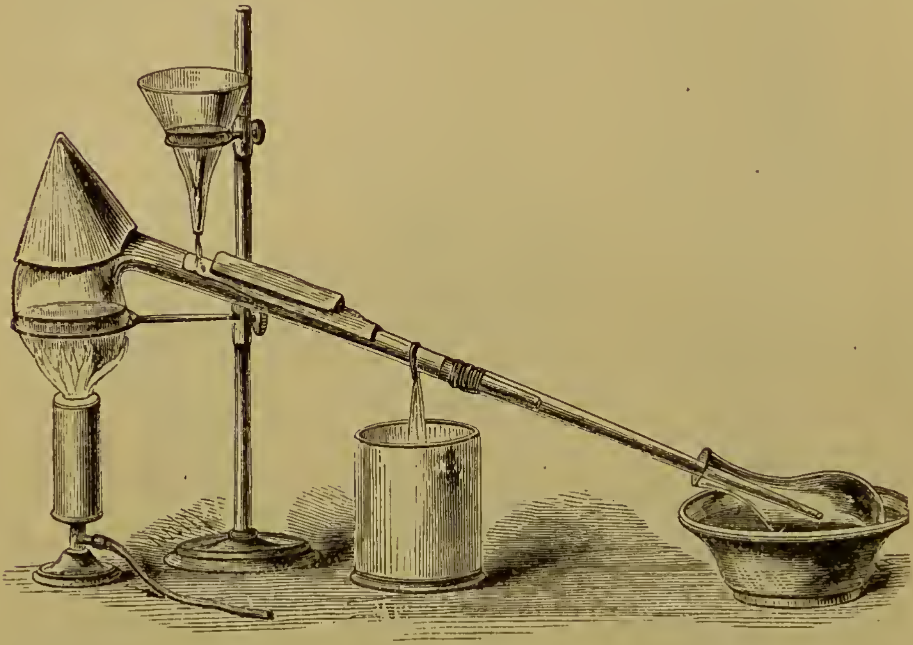
In substances which will bear a red heat without decomposition, the amount of water they contain may be determined by heating them in a tube with perfectly dry *carbonate of lead*, and receiving the water in a properly arranged chloride of calcium tube.

DEXTRINE. The name of a species of gum into which starch is converted by heating it in an oven, and which is extensively used by calico-printers, &c., under the name of British gum. Its composition is expressed by the formula ($C_6H_{10}O_5$). It derives its name from its effect upon polarized light, its solution turning the plane of polarization to the right.

Distillation. The operation which is performed on a liquid when it is desired to collect the evaporating substance. It must obviously, therefore, be conducted in an apparatus in which the vapour as it rises can be refrigerated, and again reduced to a liquid state and collected in a separate vessel.

The general process of distillation is represented in fig. 65. The bend of the retort is protected from the cooling influence of the air by a thick paper or cardboard cone, with a broad notch to admit the neck, the end of which is connected with a long tube, either by means of a cork or occasionally by cement; or without cement, the junction being made tight by strips of moistened bladder or sheet caoutchouc, and the end of this tube enters the mouth of the vessel into which the distilled products are received. The receiver is plunged into a basin of cold water, in which lumps of ice are floating. In order to liquefy the vapour rising from the retort as soon as possible, several folds of bibulous paper are wrapped round the neck, just below the bend; and lower down, just above the point where the neck enters the adapter, a ring of tow is tied, the ends of which are caused to hang down four or five inches. Cold water is supplied to this paper from a large funnel containing a filter placed immediately above it, or in such a position that the drops of water shall fall on and spread over the paper, which will

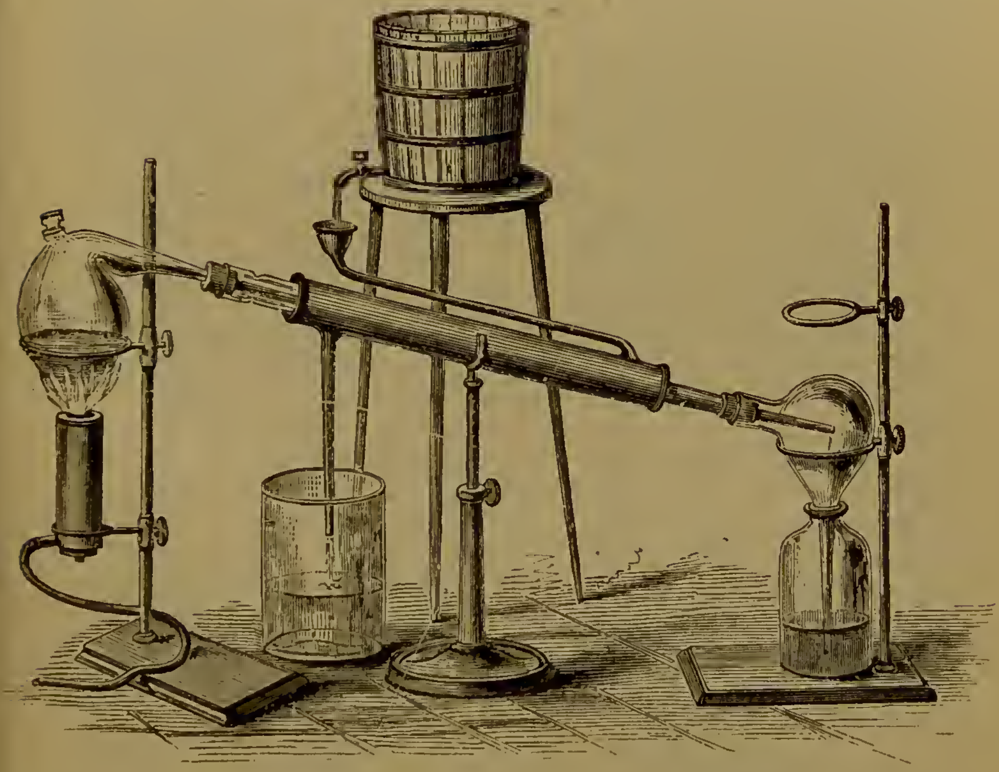
Fig. 65.



soon become saturated, and the water will run down to the tow, from which it will descend and be caught in a vessel placed beneath; and, provided it does not flow in too rapid a stream, none will enter the flask.

In cases where the products are not easily condensed, LIEBIG'S condenser, shown in fig. 66, is a very useful and convenient arrangement, and is applicable in all cases where an open apparatus is inadmissible. The condenser is a hollow metallic or glass cylinder, through the centre of which a glass tube passes, being fixed water-tight by means of perforated corks covered with cement. This tube is connected either by a cork or by tubing with the beak of the retort; a constant stream of water is caused to flow from the reservoir placed above, down the funnel, thus entering the cylinder at its lowest part. The water, warmed by the condensation of the vapour, flows out through the vertical tube underneath the upper part of the cylinder; the whole apparatus is thus kept constantly cool.

FIG. 66.



When it is desired to conduct the gaseous products of distillation into vessels containing water or other liquids, as in the preparation of hydrochloric and sulphurous acids. solution of ammonia, &c., an arrangement such as represented in fig. 67 is frequently used. It consists of a series of vessels placed side by side and connected by tubes in such a manner that the tube originating in one vessel descends nearly to the bottom of the vessel following it. A simple inspection of the figure will show the direction in which the current is supposed to be passing. After having acted on the water or solution in the first bottle, it passes through the bent tube into the second, and thence to the third. This arrangement has received the name of 'WOOLFE's Apparatus.'

FIG. 67.

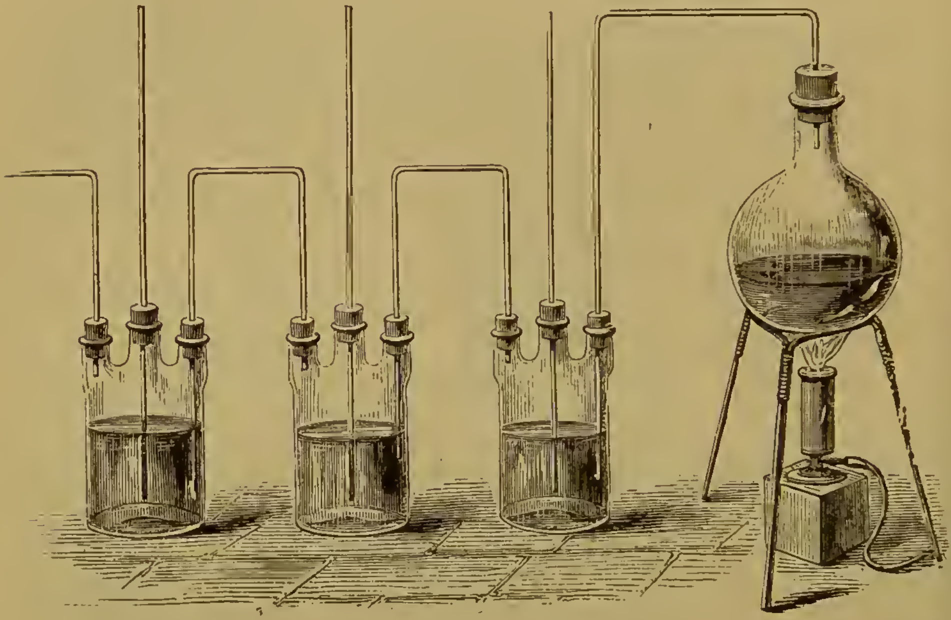
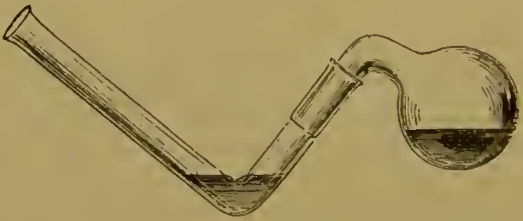


FIG. 68.



It is sometimes required to collect for examination the uncondensible elastic fluids evolved during distillation, besides the liquid results. The object in such cases is readily attained by bending the delivering tube of the third bottle into a curve, and bringing it under the shelf of the hydro-pneumatic or the mercurio pneumatic trough. When the operation is conducted on a small scale, the receiver may be made out of a piece of tube bent in the manner represented in fig. 68. The distillation is conducted precisely in the same manner as with an ordinary retort and receiver.

Efflorescence (from *efflorescere*, to blossom). Formation of small acicular crystals, like a fine moss or mouldiness, on the surface of bodies, which is produced by the evaporation or loss of water from saline substances.

Elutriation (from ἤλυτροον, *aqueduct*) signifies to decant from one vessel into another. By this process a mixture of heavy and light particles may be separated from each other by stirring the mass with water and carefully decanting it. The water carries off the lighter particles, whilst the heavier parts subside to the bottom. Metallic ores are separated from their gangue in this way.

Empyreumatic (from ἐμπυυόω, *I burn*). Name of a disagreeable and peculiar odour produced by submitting organic substances to destructive heat in close vessels, and therefore out of contact of air.

Filter, *a strainer*. To filter is to strain through linen, paper, or any suitable material. This is an operation of constant occurrence in analytical experiments. It consists in separating the solid particles which may be mixed up with, or suspended in a liquid. This is generally effected by cutting circular discs of good white filtering-paper of the required size, and folding it twice in opposite directions, so as to bring the four quadrants together; one quadrant is then opened out from the three, so as to produce a conical cup, as shown in fig. 69. The paper thus prepared is placed inside a glass funnel, taking care that it does not extend beyond or even quite reach the edge of the funnel. In qualitative experiments, where it is desirable to expedite the operation as much as possible, and in cases where a large quantity of a bulky precipitate has to

Fig. 69.

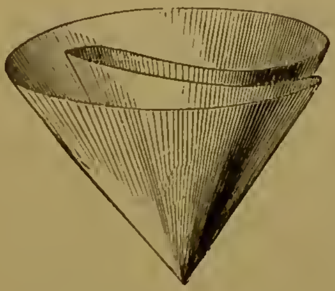
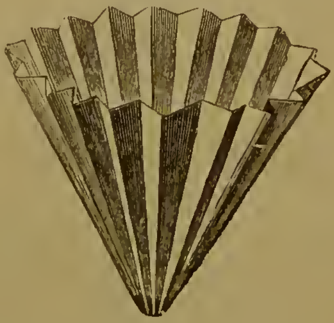
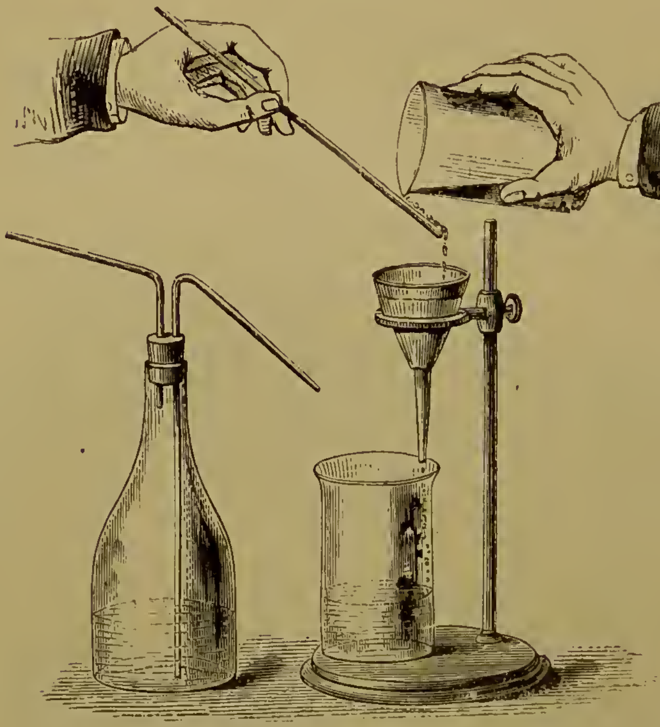


Fig. 70.



be separated, the filtrate being the valuable part, the filter may be plaited, as shown in fig. 70, so as to prevent its close adhesion to the glass. Ribbed funnels are also sometimes employed for the same purpose. The funnel, during the operation of filtering, is placed on the ring of a retort-stand or any other form of holder, and the fluid, if in a beaker, is carefully poured down a glass rod, in the manner shown in fig. 71. The edge of the beaker is greased, by which the adhesion of particles of the liquid is prevented, and all loss from trickling down the outside of the glass obviated. The clear fluid, as it drops from the funnel, should not be allowed to fall directly into the receiving vessel, but caused to impinge on its side, as shown in the figure. By attending to this we avoid all risk of loss by the splashing of the liquid.

FIG. 71.



GANGUE. Portions of rock or earth which adhere to a metallic one.

GRAVITY (*Specific*). The relative weight of a body of a certain volume compared to another body of the same volume taken as a standard. It expresses, therefore, the proportion or quantity of matter contained in a body, compared with the proportion or quantity of matter contained in another body of the same bulk.

The specific gravity of solid and liquid bodies is compared with that of pure distilled water at the temperature of 60° F. One cubic foot of such water weighs 1,000 ounces, and its gravity being taken as the unit or point of comparison, is marked thus, 1·000. When, therefore, we find the specific gravity of *mercury*, for example, represented by 13·58, and that of *bar-iron* 7·788, it means that mercury is $13\frac{58}{100}$ times, and bar-iron $7\frac{78}{1000}$ times, heavier than water; or, in other words, that whilst one cubic foot of pure distilled water weighs 1,000 ounces, one cubic foot of mercury weighs 13,580 ounces, and one cubic foot of bar-iron 7,788 ounces.

The method of taking the specific gravities of bodies is described in all treatises on Chemistry.

Heat (*Sources of*). Where coal-gas can be obtained, there is nothing so convenient or so cheap. When gas is allowed to mix with a sufficient quantity of atmospheric air to effect a complete combustion of its carbon, it burns with a flame which, though having but little luminosity, possesses great heat, and throws off no solid charcoal on cold bodies held over it. It is thus admirably adopted for the ignition of crucibles. The simplest arrangement of the coal-gas jet for this purpose is shown in fig. 72. The mixture of gas and air takes place in the copper cylinder, and it is inflamed above the wire gauze fastened over the top. The crucible to be heated is supported on a triangle of platinum wire laid across the ring of the retort-stand. But the gas-burner now most generally used in the chemical laboratory is that invented by Professor Bunsen, and shown in fig. 73. The gas is supplied through the horizontal tube, whence it passes through a set of small holes into the box, *a*, in which it mixes with atmospheric air that enters freely by the holes shown in the sketch. The gaseous mixture passes up the vertical tube, *b*, and is inflamed at the top, where it

Fig. 72.

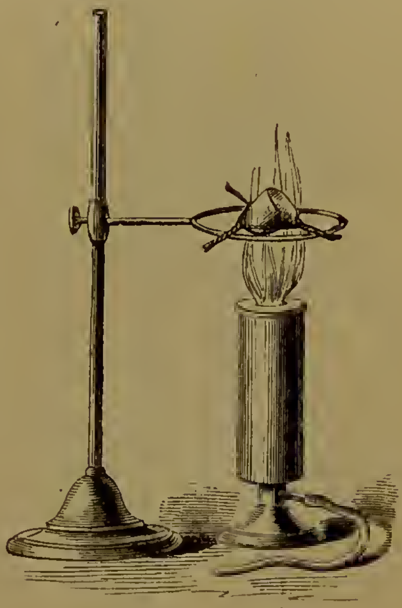
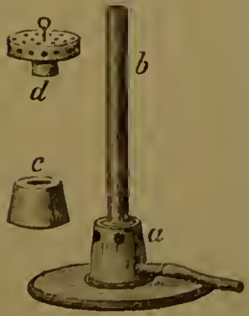


Fig. 73.



burns with a single tall blue flame, which produces no smoke and gives very little light, but much heat. *c* represents a thin brass cap which fits the air-box, *a*, but moves easily round it; *d* is a flat cast-iron box, with many holes round the margin and a few small ones on the top. This box fits loosely on the upper part of the tube, *b*, and when it is placed upon it and the gas is lighted, the flame produced consists of a series of radiating jets as shown in fig. 74, in which *a* represents the horizontal flames and *b* the single vertical flame.

FIG. 74.

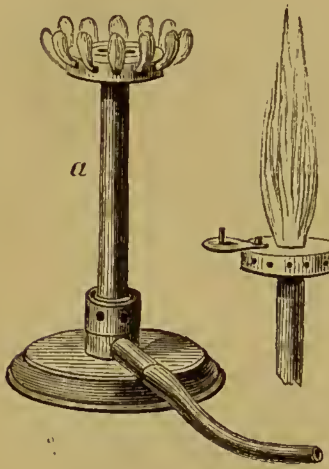


FIG. 75.

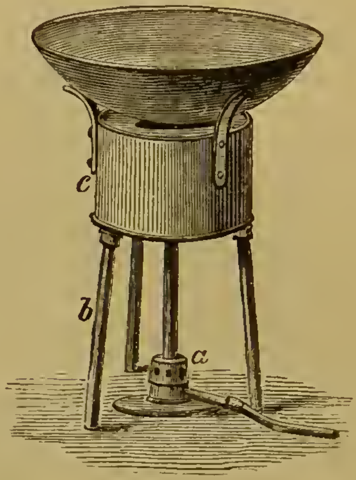
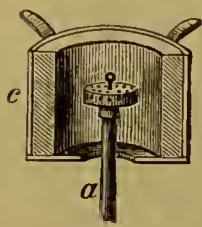


FIG. 76.



In figs. 75 and 76 are represented Mr. GRIFFIN's arrangement for boiling and evaporating, by his modification of the BUNSEN burner. *a* is the gas-burner (its position shown in section in fig. 76), *b* an iron stove with three legs, *c* a furnace body or iron jacket lined with plumbago or fire-clay. Fig. 76 shows the jacket and lining in section, and marks the position of the fire-box, *d*, of the gas-burner. The burner thus arranged, and supplied by a gas-pipe of $\frac{1}{4}$-inch bore, burns about 33 cubic feet of gas in an hour, and will boil two gallons of water in an open porcelain evaporating basin in half an hour.

Mr. GRIFFIN's arrangement for heating to redness a large fire-clay crucible is shown in perspective in fig. 77, and in section in fig. 78.

The gas-burner is to be used without the fire-box, *a* (fig. 79), and is to be arranged with the furnace fittings that are represented in perspective by fig. 77, and in section by the lower part of fig. 78, *a*, *b*, *c*, *d*. Letter *a* represents the gas-burner; *b* is a tall iron stool; *c* a chimney which collects atmospheric air to feed the flame; *d* is a furnace-sole or plate of fire-clay; *f* is a reverberatory dome, the interior of which is best shown in section in fig. 79; *i* is a cast-iron ring or trivet, represented more clearly

FIG. 77.

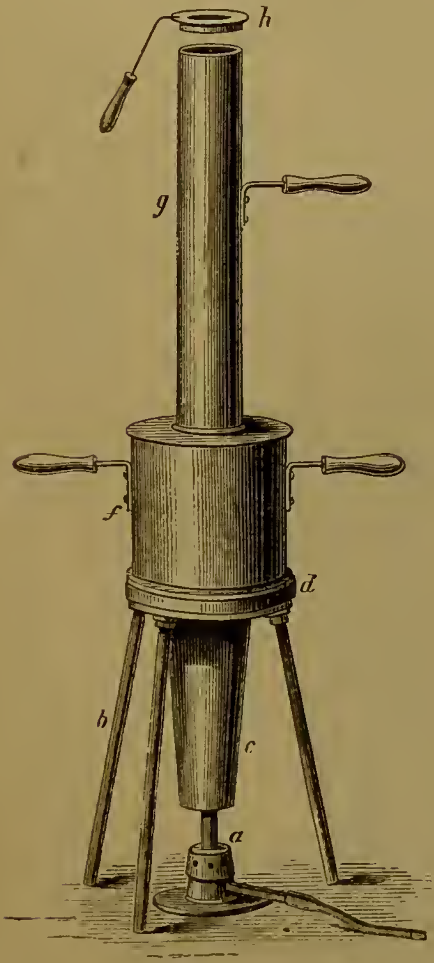


FIG. 78.

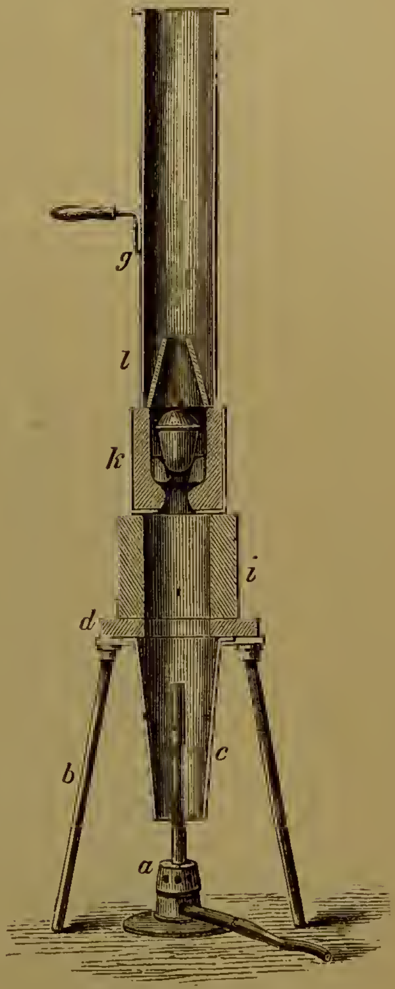


FIG. 79.

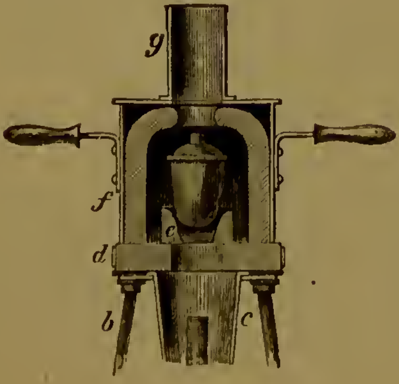
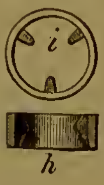


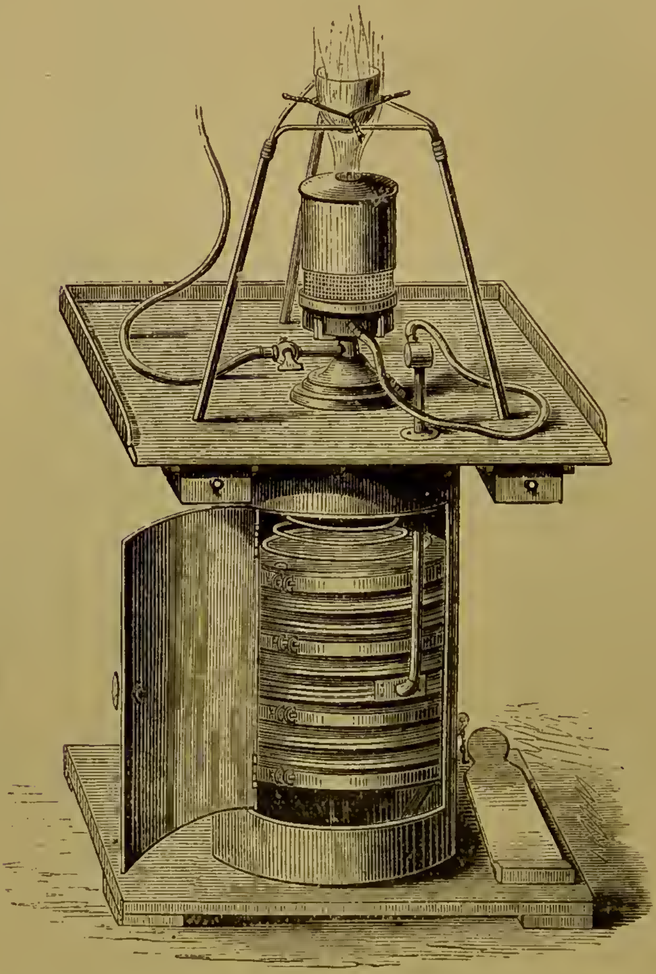
FIG. 80.



in fig. 80; *g* is an iron chimney 24 inches long and 3½ inches wide, and *h* a damper, to lessen the draught when small crucibles are to be heated. The gas should be lighted after the crucible is placed in its position, and before the dome is put on.

In this furnace a small gas flame produces a powerful effect, because very little heat is lost by radiation or conduction.

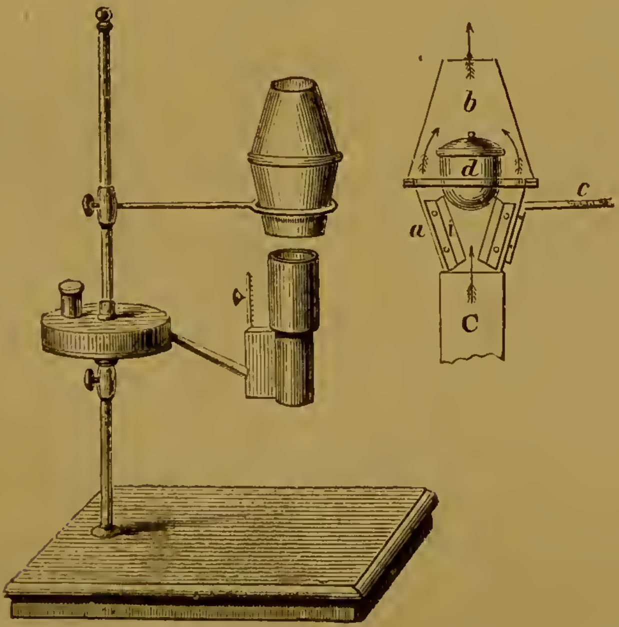
FIG. 81.



The furnace is represented in section in fig. 79. *a* is the gas-burner; *b* the stove; *c* the air-chimney; *d* the furnace-sole: *i* a cylinder of fire-clay 4 inches high and 4½ inches in diameter: *k* a plumbago or fire-clay furnace, in which is placed a small cast-iron ring, and on this ring the platinum crucible is adjusted: *l* is a fire-clay or plumbago reverberatory dome; and *g* is the chimney. In this furnace 1,000 grains of anhydrous carbonate of sodium may be fused, and small quantities of sterling silver may be melted in a clay crucible.

Normandy's gas blow-pipe furnace is shown in fig. 81. It consists of a wire-gauze cylinder, partly cased in sheet iron, in communication at the lower part with the atmosphere, closed at the upper end by a diaphragm of wire gauze of about 700 openings to the square inch, and provided with a short slightly conical cover, perforated in the centre. A blow-pipe jet placed outside the cylinder traverses the diaphragm, and opens on a level with the aperture in the cover; a blast of air is sent into the centre of the flame by means of a flexible tube of vulcanized caoutchouc from a bellows, as shown in the figure. A flame is thus produced of considerable intensity, and well adapted to most of the requirements of the laboratory.

Fig. 82.



A useful form of Berzelius's spirit-lamp is shown in fig. 82, he reservoir containing the spirit being at a distance from the burner, whereby it escapes being heated during long operations. The crucible is surrounded by an iron jacket, *a*, *b*, *c*, which protects it from the cooling influence of the surrounding air.

Aikin's portable blast-furnace is shown in fig. 83. It is generally made out of black-lead pots, three being used for the purpose. The lower part of the first one serves as a resting-place for the body of the furnace; it has a hole drilled through it, by which air is supplied by a bellows to the body of the furnace, which is another crucible placed above the lower one, in which several holes are drilled to admit air. Over the second crucible a third is inverted, with a large hole cut in the side for the escape of smoke and gaseous matters. Cast iron may be melted in this furnace, and moderate-sized crucibles brought to a full red heat in a few minutes.

FIG. 83.

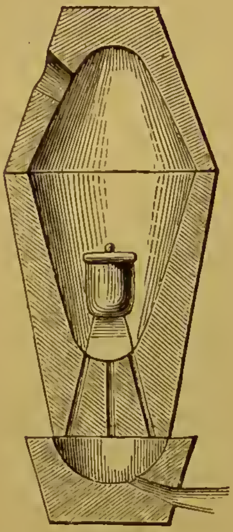
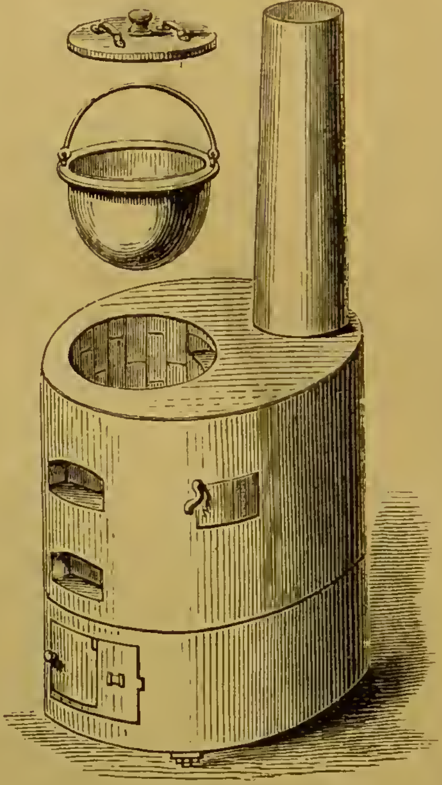


FIG. 84.



The furnace represented in fig. 84 is known as BLACK's furnace, and is on the whole perhaps the most convenient where a stationary furnace is required. It consists of a case of strong sheet iron, lined with refractory clay. The grate is fixed to the iron plate which supports the chimney, and forms the top of the ash-pit, which is provided with a sliding door for the admission of air. There are various apertures in the front and sides of the furnace for the admission of tubes, crucibles, &c. The fuel used is coke.

HYGROSCOPIC (from ὑγροσ, *moist*, and ςκοπέω, *I watch*) means the moisture which substances absorb spontaneously from the atmosphere. The instrument by which the quantity of moisture contained in the air is approximately ascertained is called a hygroscope.

HYDRATE (from ὕδωρ, *water*). Compounds resulting from the union of acids, of bases, or of salts, with water in fixed and determinate proportions.

IGNITION. The heating of substances, such as precipitates *e.g.*

to redness, generally for the purpose of eliminating volatile substances before weighing, but sometime also for modifying the state of certain bodies. Ignition is carried on in the laboratory in crucibles, or capsules of platinum, or of silver, or of porcelain, as the case may be. (See *Heat, Sources of.*)

INSPISSATE. To thicken a liquid containing a substance in solution, by boiling off a portion of the liquid. Vegetable extracts are *inspissated* juices.

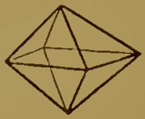
LEVIGATION (from *levis*, light). To reduce a substance into an impalpable powder. This is done by grinding the substance reduced to a paste, with water or some other liquid, upon a flat stone or slab, with a muller.

NACREOUS is said of the lustre of mother-of-pearl, and of all substances which have that appearance.

NEUTRALIZATION. When an acid and a base are made to react upon each other: as, for example, when soda is poured into sulphuric acid in such proportions that the liquor no longer reddens litmus-paper nor turns turmeric-paper brown, they are said to be neutralized, and the result of the combination is a salt which, in the present instance, would be GLAUBER's salt (sulphate of sodium).

OCTAHEDRON. Crystal having eight faces. We give here (fig. 85) the form of the regular octahedron.

FIG. 85.



ORGANIC. Substances belong to the vegetable, to the animal, or to the mineral kingdom. Those which belong to the animal or vegetable kingdom being organized, that is living bodies, are called *organic* bodies. The minerals, which are inert or inorganized bodies, are called *inorganic* bodies.

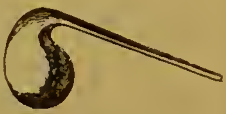
PORPHYRIZE (TO). To grind upon a slab or in a mortar of porphyry, in order to reduce hard substances into an impalpable powder.

PRECIPITATE (from *precipitare*, to fall down), is the name given to substances which have been separated from their solution in a solid state. Thus, for example, if solution of sulphate of sodium, or dilute sulphuric acid, be added to a solution of acetate of lead, a white powder, which is sulphate of lead, will fall down, or, in chemical language, will be *precipitated*.

REAGENT is the name given to any substance which, in the course of chemical analysis, may be employed to detect the presence of other substances. For example, if a little infusion, or tincture of nutgalls, be poured into a liquor containing a salt of peroxide of iron, a purple-black colour (ink) will appear; infusion of nutgalls is therefore a reagent for peroxide of iron. If a drop of acid be poured into a blue solution of litmus, the solution instantly becomes red; litmus is therefore a reagent for acids.

RETORT. A chemical vessel of the annexed shape (fig. 86). (See *Distillation.*)

FIG. 86.



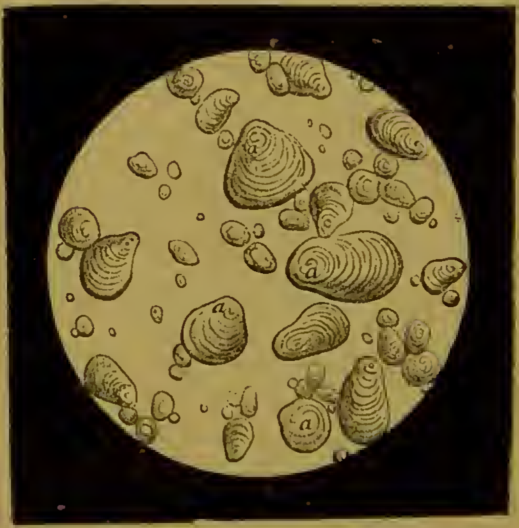
SALIFIABLE BASES. Substances which, by combining with acids, can form salts.

SALTS. In a general sense compounds resulting from the action of an acid upon a base (see *Base*), or from the action of two substances on each other, one of which acting as an acid neutralizes the other, which then acts as a base. An *acid salt* is a salt in which the acid is in excess; a *basic salt* is a salt in which the base predominates.

SOLVENT. Any substance which will dissolve another. Water is a solvent of sugar, and of a vast number of substances; ether is a solvent of bromine; mercury is a solvent of gold, silver, tin, &c.; melted zinc is a solvent of copper.

STARCH.—A substance universally diffused in the vegetable world, and found also in the animal organism. It is found in seeds, roots, tubers, and bark; in pulpy fruits and in the expressed juice of most vegetables. The common starch is derived from wheaten flour, fecula or potato-starch from that root.

FIG. 87.



Tapioca, derived from the root of *Jathropa manihot*, *arrow-root* from that of *Maranta arundinacea*, *sago* from the stem and pitch of *Sagus farinifera Rumphii*, are severally mere varieties identical with starch in their chemical composition.

If flour be mixed up and kneaded in a cloth with water, a whitish liquid will be strained off, which, being left to settle, will deposit starch. The substance retained by the cloth, called *gluten*, which is white and insoluble in water, is nitrogenous, and is the constituent on which the value of meal as an article of food chiefly depends.

Starch is a snow-white glistening powder, which crackles between the fingers. When submitted to the microscope it appears to consist of transparent ovoidal grains, the magnitude of which varies in different plants, those of the potato being greatest, those of leguminous seeds (such as peas), less, and those of wheat and rice smaller still.

When the fecula of the potato is submitted to the microscope it presents the appearance shown in fig. 87. Each grain presents at its surface a peculiar point, *a*, called the *hile*, round which the matter is disposed concentrically in layers or strata with a certain regularity. If a grain be compressed between two slips of glass it will be broken into several fragments (fig. 88), the planes of fracture having their common intersection in the hile. Each grain consists of a succession of thin pellicles, which may be exfoliated by heating the fecula to about 400° F. (fig. 89).

FIG. 88.

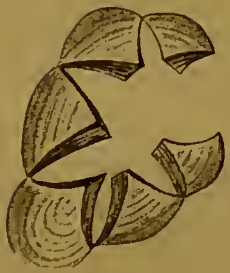
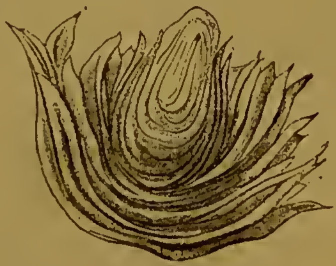


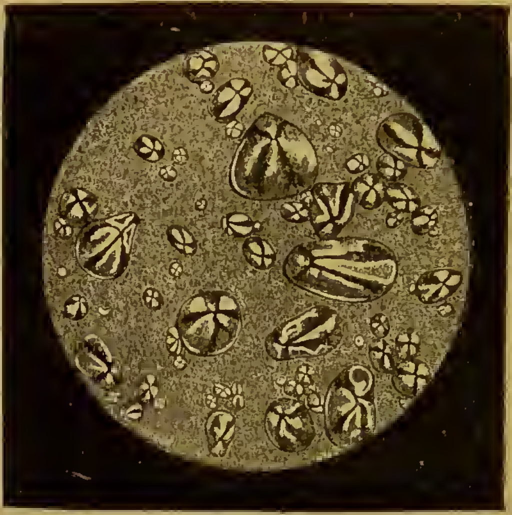
FIG. 89.



The symmetrical arrangement of the anhydrous molecules around the hile is rendered very apparent when the grains of fecula are submitted to polarised light, and a prepared rhomb of Iceland spar is interposed between the object and the eye. A black cross is then observed, the centre of which coincides with the hile, and which is analogous to those which are seen through thin crystals, having a single axis at right angles to which they have been cut.

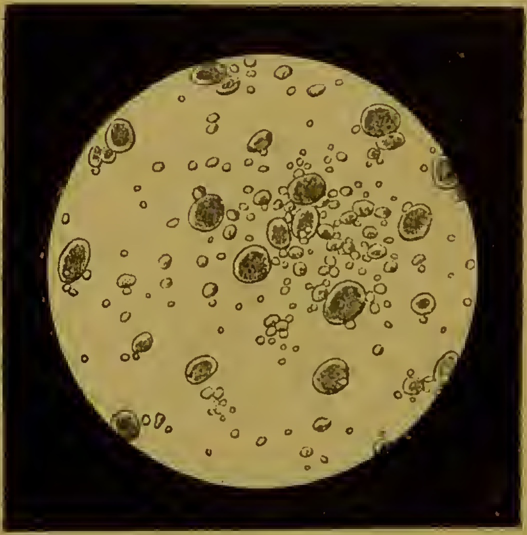
The grains already shown in fig. 87 by common light, assume in polarized light, when viewed in the manner here explained, the appearance shown in fig. 90.

FIG. 90.



The amylaceous granules of different vegetables present different appearances, by which they may be easily identified by a practised eye. This is rendered apparent by inspecting figs. 87, 91, 92, and 93, the first showing the granules of the potato, the second those of wheat, the third of peas (*a* dry and *b* green), and the fourth those of maize. The fecula of the potato is more

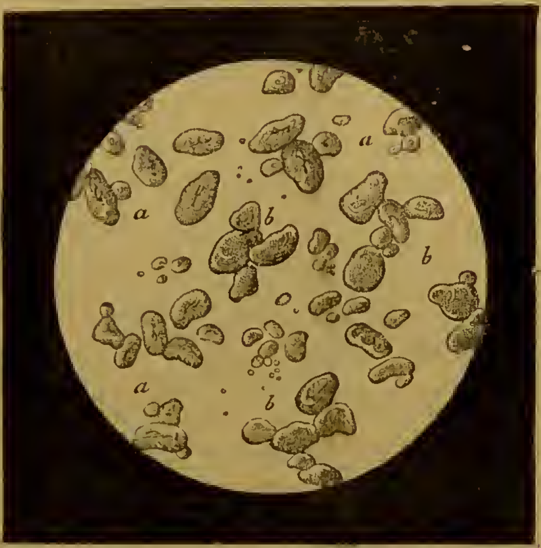
FIG. 91.



certainly and easily distinguished, being the only amylaceous granule which gives the black cross with polarized light.

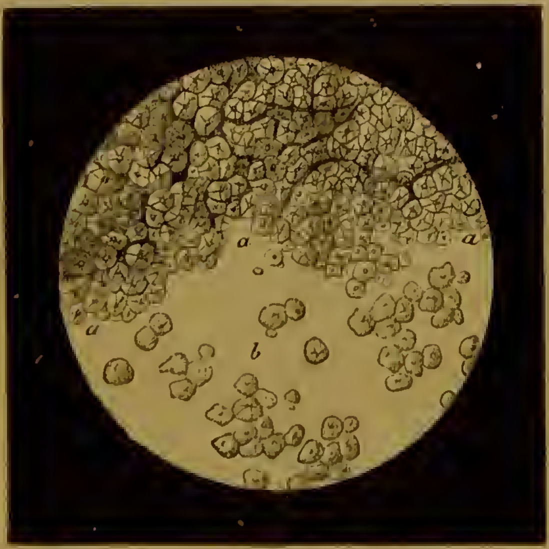
The following are the relative magnitudes of the granules of different vegetables expressed, in their lengths, in hundred thousandths of an inch :—

FIG. 92.



Potato . .	740	Wheat . . .	180	Millet . . .	40
Bean . . .	300	Spanish potato .	160	Parsnip . .	28
Sago . . .	200	Maize . . .	100	Grain of Beet	16

FIG. 93.



If starch be put in 15 times its volume of water, of which the temperature is then gradually raised, a part of the granules will begin to dilate, and will burst when the temperature rises to 140°. This disintegration is accelerated as the temperature is further elevated, and when it approaches 212° all the granules are exfoliated, and so enlarged that they fill the entire volume of the liquid, which is thus transformed into the gelatinous paste used for starching linen and pasting and sizing paper.

The conversion of the fecula into gelatinous paste is accelerated by adding 1 or 2 per cent. of caustic potash or soda to the water.

When the dilute acids act on starch at 212° the amylaceous matter is immediately disintegrated, and an isomeric change ensues, the result of which is, first, the production of a soluble substance, called *dextrine*, because it possesses right-handed polarization, and then into *glucose*, or grape-sugar, which has the same optical property.

Starch is quite insoluble in alcohol at any temperature. Though generally regarded as neutral, it is capable of combining with certain bases, such as lime, baryta, and oxide of lead.

Iodine exercises a characteristic action on starch, producing a dark blue colour, which varies in tint with the state of aggregation of the starch. It is generally blue, but sometimes violet, and when the starch has undergone partial disintegration it becomes red. Exposed to light the iodide of starch is discoloured, the iodine being converted into hydriodic and iodic acids (GUIBOURT). When iodide of starch in suspension in water is raised to a temperature of 150° it becomes colourless, but recovers its colour when cooled (LASSAIGNE).

When iodide of starch is discoloured by exposure to solar light, the colour may be restored by some drops of chlorine, which, decomposing the hydriodic acid, liberate the iodine, which again combines with the starch and colours it. Alkaline solutions seizing on the iodine also discolour the iodide, the colour being restored by an acid, which, seizing on the alkali, liberates the iodine.

Neither acetic acid nor ammonia has any action on starch.

Fuming nitric acid forms with starch a compound called *xyloidine*, insoluble in water.

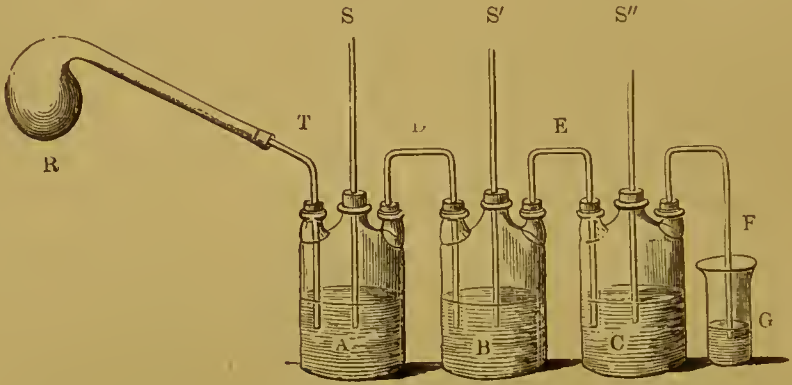
SUBLIMATE (from *sublimis*, high), is the result of a dry distillation, in consequence of which the substance, after having risen in vapour by the action of the heat, condenses in the upper or cold parts of the vessels. Thus, if sulphur be heated in a flask, the fumes will rise and condense in the upper part of the flask in the form of a yellow powder, which is sublimed sulphur, commonly called flowers of sulphur.

TEST PAPERS. Papers which have been dipped in solution of certain vegetable colouring matters, or of certain solutions of metallic salts, capable of assuming a distinctive or characteristic colour when put in contact with other substances for which they are used as a test of their presence. Thus, paper tinged blue with tincture or with aqueous solution of litmus turns red when put in contact with acids. Paper tinged yellow with the solution of turmeric turns brown by contact with alkalies. Paper dipped in solution of red cabbage is gray, but it turns bright red by contact with acids, and bright green by contact with alkalies. Paper which has been immersed in solution of acetate of lead, turns black by contact with sulphuretted hydrogen. Paper which has been immersed in solution of ferrocyanide of potassium turns blue by contact with a solution of a salt of iron. Paper dipped in solution of ferricyanide of potassium turns blue by contact with a solution of a protosalt of iron, but is not altered by one of a persalt of iron, &c., &c.

VOLUME is the name given to the space occupied by the pores and molecules of which bodies consist. It is important not to confound the *mass* of a body with its *bulk* or *volume*. The term volume refers only to the dimensions of the body, and it always expresses the place which the body occupies in space. The density or gravity of a body is more or less considerable in proportion as the matter of the body is more or less compact which determines its weight. The *mass* of a body, however, depends, at the same time, upon its volume and its density, and is represented by the weight. Two bodies of the same weight have necessarily the same mass. A pound of lead has the same mass as a pound of cork or of down; but cork and down being much less dense than lead, are much larger in bulk or volume than the latter.

WOOLFE'S APPARATUS. From the name of the inventor; is an apparatus which consists of several tubulated vessels, for the purpose of facilitating the absorption of gases by liquids. These flasks or vessels are so disposed and connected by air-tight tubes, that the gas which has not been absorbed by the liquid contained in the first flask, traverses that contained in the second, and then that of the third, and so on. We represent the apparatus on page 474. R is the retort from which the gas to be absorbed is disengaged, and is connected with the bottles A, B, C, as represented. A, B, C, are bottles with three tubulars or openings, fitted with perfectly air-tight corks, which are perforated for the admission of the various tubes. The bottles A and B, B and C, are connected together by tubes of glass, or partly of glass and of vulcanized or of ordinary caoutchouc at D and E. The straight tubes S, S′, S″, are safety-tubes, the object of which is to prevent absorption. The tube T, D, E, should only dip a very short distance into the liquor in the bottles, otherwise the first bottle would have to bear a more or less considerable pressure, which might force the corks out. Suppose, in effect, that the said tubes, T, D, E, F, were to plunge into the liquid of their respective bottles, the first $\frac{1}{8}$ of an inch, the second $\frac{2}{8}$ of an inch, and the third $\frac{3}{8}$ of an inch; and lastly, that the tube F plunges $\frac{4}{8}$ or $\frac{1}{2}$ of an inch deep into the liquid of the glass beaker, G. It is easily conceived that the pressure would be equal to the weight of a column of liquid $\frac{1}{2}$ inch high, in the beaker G; $\frac{4}{8} + \frac{3}{8}$, or the weight of a column of liquid, $\frac{7}{8}$ of an inch high in bottle C: $\frac{4}{8} + \frac{3}{8} + \frac{2}{8}$, or $\frac{9}{8}$ of an inch pressure in bottle B; $\frac{4}{8} + \frac{3}{8} + \frac{2}{8} + \frac{1}{3} = \frac{10}{8}$, that is $1\frac{1}{4}$ in. pressure in the first bottle. Wherefore, if a great number of bottles were used, it is necessary to take care that the tubes only reach a short depth down into the liquid of the bottles or jars.

FIG. 94.



APPENDIX A.

☞ *The following articles were accidentally omitted from the text of the book:—*

ACETATE OF LEAD (Sugar of Lead, Salt of Saturn).—Acetate of lead is used in various arts, especially in dyeing and in calico printing, and is on that account an important article of commerce. The salt is generally met with in white circular crystalline lumps, of a sweet and astringent flavour, poisonous; efflorescent; and soluble in 0·59 parts of water at 600° F., and in 8 parts of alcohol. Its aqueous solution is partially decomposed by the carbonic acid of the air, carbonate of lead being precipitated and a portion of acetic acid set free, which prevents further decomposition.

The acetate of lead of commerce sometimes contains *acetate of calcium*, the presence of which may be detected by dissolving a portion of the sample in water; passing a stream of sulphuretted hydrogen gas through the solution, in order to precipitate the whole of the lead in the state of sulphide (black); filtering, and testing the filtrate with a solution of oxalate of ammonium, which will produce a precipitate of oxalate of calcium; the liquid should be warmed and left at rest until the precipitate has well settled, then collected on a filter, washed, dried, gently ignited, and then treated with excess of sulphuric acid, whereby it is converted into sulphate of calcium. After ignition, 68 grains represent 28 grains of lime, and consequently 79 of acetate of calcium.

If, after saturating the filtrate with ammonia, the liquor becomes blue, it is owing to the presence of *copper*; if it remains colourless, but becomes black by the further addition of sulphide of ammonium, it is owing to the presence of *iron*. The proportion of these impurities is, however, generally very trifling.

BICARBONATE OF POTASSIUM.—This salt is often adulterated or mixed with neutral carbonate of potassium; sometimes, also, it contains chloride of potassium or of sodium, or sulphate of potassium. If the quantity of neutral carbonate is at all considerable, and provided chloride of sodium is absent, a solution of corrosive sublimate (bichloride of mercury), added to a moderately concentrated aqueous solution of the salt under examination, will produce a brick-red precipitate; whilst, if no neutral carbonate is present, only a slight precipitate or turbidity will appear. Moreover, considering that bicarbonate of potassium produces no precipitate in solutions of salts of magnesium, whilst the neutral carbonate does produce one, the presence of the latter substance may be readily detected by dissolving a portion of the sample in water and testing the liquor with a solution of sulphate of magnesium, which, if a precipitate be formed, is carbonate of magnesium, and is due to the presence of neutral carbonate of potassium.

Bicarbonate of potassium is not deliquescent, except when it contains a portion of the neutral carbonate of the same base.

If a portion of the sample, being dissolved in water and supersaturated with pure nitric acid, produces when tested by a solution of nitrate of silver a white curdy precipitate soluble in excess of ammonia, it is chloride of silver, and of course proves the presence of a soluble chloride. The chloride of silver may be collected on a small filter, washed, dried, and fused in a porcelain crucible, and then weighed. 143·5 of chloride of silver = 75·5 of chloride of potassium, or 1 equivalent of any other chloride.

If sulphate of potassium (or of sodium) is present, it may be detected by pouring into the solution of the sample, acidified with pure nitric acid, some solution of nitrate of barium, which, if it produces a white precipitate insoluble in water and in acids, is sulphate of barium, and indicates that the sample contains a soluble sulphate. 116·5 of sulphate of barium = 87 of sulphate of potassium, 72 of sulphate of sodium, or 1 equivalent of any other soluble sulphate.

Bicarbonate of potassium being entirely soluble in water, all that which may remain insoluble is impurity.

BINOXALATE OF POTASSIUM (Salt of Sorrel).—This salt is obtained from the acid juice of certain plants (*Oxalis acetosella*, *Oxalis erniculata*, *Rumex acetosa*, &c.), and is manufactured on a large scale in Switzerland and certain parts of Germany. The salt has an acid taste, and when ignited it emits very pungent acid fumes, but is not charred. The binoxalate of potassium of commerce is sometimes falsified with cream of tartar, and sometimes also with bisulphate of potassium. The presence of cream of tartar (acid tartrate of potassium), or in fact of any other organic substance, is recognised by the peculiar odour of burning bread which is emitted when the salt is ignited in a platinum crucible, pure binoxalate of potassium emitting when thus heated only white and acid fumes, but not being charred. There remains after ignition a greyish residue, which is carbonate of potassium. Cream of tartar may also be detected by boiling a portion of the binoxalate of potassium under examination with concentrated sulphuric acid, by which it is decomposed and dissolved, a rapid disengagement of carbonic acid and carbonic oxide gas taking place at the same time, the solution, however, remaining colourless if the salt be pure; but if, on the contrary, after boiling the suspected salt for some time, the liquor turns brown, then it is a proof that tartaric acid or organic matter is present. The presence of bisulphate of potassium is detected by dissolving a portion of the salt in pure water, and testing with solution of chloride of barium, which will produce a precipitate insoluble in water and in acids.

APPENDIX B.

THE FOLLOWING TABLES WILL BE FOUND USEFUL FOR REFERENCE:—

TABLE I.

French Measures of Surface, with their English Equivalents.

	In English Square Feet	In English Square Yards	In English Acres =43560 Square Feet
Centiare, or Square Mètre	10·764299	1·196033	0·0002471
Are, or 100 Square Mètres	1076·429934	119·604326	0·0247144
Hectare, or 10,000 Square Mètres . . .	107642·993418	11960·332602	2·4711431

1 square inch = 6·4513669 square centimètres;
1 square yard = 0·83609715 square mètres;
1 square foot = 9·2899683 square décimètres;
1 acre = 0·40467102 hectare.

TABLE II.

French Measures of Weight, with their English Equivalents.

	In English Grains	In Troy Ounces =480 Grs.	In Avoirdupois Pounds = 7000 Grs.	In Cwts. = 112 lbs. =784.000 Grains	Tons =20 Cwt. =15.680,000 Grains
Milligramme	0·01543	0·000032	0·0000022	0·0000000	0.000000001
Centigramme	0·15432	0·000322	0·0000220	0·0000002	0·00000001
Decigramme	1·5423	0·003215	0·0002205	0·0000020	0·0000001
Gramme .	15·43235	0·032151	0·0022046	0·0000197	0·0000010
Dekagramme	154·32349	0·321507	0·0220462	0·0001968	0·0000098
Hectogramme	1543·23488	3·215073	0·2204621	0·0019684	0·0000984
Kilogramme .	15432·34880	32·150727	2.2046213	0·0196841	0·0009842
Myriogramme	154323·48800	321·507267	22·0462126	0·1968412	0·0098421

1 grain = 0.064799 gramme; 1 troy ounce = 31·103496 grammes;
1 lb. avoir. = 0.453495 kilograms; 1 cwt. = 50·802377 kilograms.

TABLE III.

French Measures of Capacity, with their English Equivalents.

	In Cubic Inches	In Cubic Feet =1728 Cubic Ins.	In Pints =34·65923 Cubic Ins.	In Gallons =8 Pints =277·27384 Cubic Ins.	In Bushels =8 Galls. =2218·19078 Cubic Ins.
Millilitre, or Cubic Centimètre . .	0·06103	0·000035	0·00176	0·0002201	0·0000275
Centilitre, or 10 Cubic Centimètres	0·61027	0·000353	0·01768	0·0022010	0.0002751
Décilitre, or 100 Cubic Centimètres	6·10271	0·003532	0·17601	0·0220097	0·0028512
Litre, or Cubic Decimètre	61·20705	0·35317	1·76077	0·2200967	0·02751208
Decalitre, or Centistère	610·27052	0·353166	17·60773	2·2009688	0·27512085
Hectolitre, or Decistère . . . . -	6102·70515	3·531658	176·07734	22·0096677	2·7512085
Kilolitre, or Cubic Mètre	61027·05152	35·316581	1760·77341	220·0966737	27·5120846
Myrcolitre, or Décastère	610270·51519	353·165807	17607·73414	2200·9667675	275·1208459

1 cubic inch=16·386176 cubic centimètres; 1 cubic foot=28.315312 cubic décimètres; 1 gallon=4·543358 litres.

A litre of distilled water weighs 1 kilogramme; a cubic centimètre of water weighs 1 gramme.

TABLE IV.

French Measures of Length, with their English Equivalents.

	In English Inches	In English Feet	In English Yards	In English Miles
Millimètre .	0·03937	0·003281	0·0010936	0.0000006
Centimètre .	0·39371	0·032809	0·0109363	0·0000062
Decimètre .	3·93708	0·328099	0·1093633	0·0000621
Mètre . . .	39.37079	3·280890	1·0936341	0·0006214
Dékamètre .	393·70790	32·808992	10·9363310	0·0062138
Hectomètre .	3937·07900	328·089920	109·3633100	0·0621382
Kilomètre .	39370·7900	3280·899200	1093·6331000	0·6213824
Myriomètre .	393707·9000	32808·992000	10936·3310000	6·2138244

1 inch=2·539954 centimètres; 1 yard=0·9143835 mètre;
1 foot=3·0479449 decimètres; 1 mile=1·6093149 kilomètre.

Comparison of Thermometric Scales.—The interval between the melting-point of ice and the boiling-point of water has in different countries been differently divided.

In England, FAHRENHEIT'S division into 180° is principally employed; the zero or 0° upon this scale being 32 of these degrees below the freezing-point of water. In France and on the Continent generally, the Centigrade division prevails; the interval between the freezing and boiling-points being subdivided into 100°, the degrees being counted upwards and downwards from the freezing-point, which is reckoned 0°; the lower temperatures being indicated by the prefix of the negative algebraic sign. Reaumur, whose division is still used in Germany and Russia, divided the same interval into 80°, making his zero at the freezing-point of water.

The conversion of degrees upon one scale into those of another is easily effected by the use of the following formula:—

Fahrenheit to Centigrade $\frac{5}{9}(\text{F.}^\circ - 32) = \text{C.}^\circ$

Example:

212° F. − 32 = 180; 180 × 5 = 900, and 900 ÷ 9 = 100° C.

Centigrade to Fahrenheit $\frac{9}{5}\,\text{C.}^\circ + 32 = \text{F.}^\circ$

Example:

100° C. × 9 = 900; 900 ÷ 5 = 180, and 180 + 32 = 212° F.

Réaumur to Fahrenheit $\frac{9}{4}\,\text{R}^\circ. + 32 = \text{F.}^\circ$

Example:

80° R. × 9 = 720; 720 ÷ 4 = 180, and 180 + 32 = 212° F.

Fahrenheit to Réaumur $\frac{4}{9}(\text{F.}^\circ - 32) = \text{R.}^\circ$

Example:

212° F. − 32 = 180; 180 × 4 = 720, and 720 ÷ 9 = 80° R.

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